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TROPICAL FOREST DEVELOPMENT PROJECTS: STATUS OF ENVIRONMENTAL AND AGRICULTURAL RESEARCH

HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

SEPTEMBER 19, 1984

[No. 143]

Printed for the use of the Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE

41-115 O WASHINGTON : 1985

H701-60

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TROPICAL FOREST DEVELOPMENT PROJECTS: STATUS OF ENVIRONMENTAL AND AGRICULTURAL RESEARCH

WEDNESDAY, SEPTEMBER 19, 1984

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT,

Washington, DC.

The subcommittee met, pursuant to call, at 10 a.m., in room 2318, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Mr. SCHEUER. The subcommittee will come to order. We apologize for the delay, but there was another committee that needed a quorum and had a very important rollcall vote, so we had to absent ourselves for this period and I apologize.

We are joined here today by Congressman Tom Lewis of Florida, one of our most diligent and hard-working members, and we hope other members will be joining us.

Today the committee will be taking a good, hard look at projects which seek to transform the vast wilderness of Latin American rain forests into productive agricultural lands, and we will also seek to analyze the role that agricultural and environment research plays in this development process.

Tropical rain forests, tropical forests, are an irreplaceable global resource. They play an important part in moderating the world's climate. They are a unique biological reserve for much of the world's genetic diversity in plant and animal species. This genetic diversity and richness is an important source of material for science, medicine, and industry.

History has shown us that tropical forests play an integral role in preserving the regional environment. When vast areas of forest are cleared by burning, the remaining ashes which contain most of the nutrients in the soil are quickly washed away by the heavy rains. Crops fail, the land is abandoned, and the soil begins heavily to erode under the onslaught of tropical sun and rains. Rivers and streams are filled with silt, resulting in reduced navigability and greater flooding during the rainy seasons. The areas, in fact, become so degraded that they become totally unproductive for any useful purpose.

Most deforestation in Latin America stems from shifting cultivation, from the practice of small, peasant farmers clearing the farm—clearing and farming—until the soil is depleted and totally

leached out, and then moving on to clear again and beginning the same destructive process.

While the demands for higher food production and the security of land ownership are readily understandable, particularly in the face of disastrous rates of population growth, research suggests that tropical forests might better serve these demands by being kept intact rather than being burned and cleared and converted into traditional agricultural cropland or rangeland.

The development of the forests appears to be a case of an all-too-familiar scenario: production now at the expense of future, long-term ecological and economic devastation.

Now, in order to get a better understanding of the causes and the effects of deforestation, today's hearings will focus in detail on the tropical forest development projects in northwest Brazil, the site of over two-fifths of the world's remaining tropical forests. We will examine the role that the multilateral development banks, the so-called MDB's, such as the World Bank, have played in the development process. While the World Bank has been sensitive to environmental issues in loaning Brazil funds for the development of this area, many observers have questioned the adequacy both of the research upon which the Bank has relied when it entered into these projects, as well as the Bank's ability to perform oversight and to enforce the terms of its agreement.

Others have suggested that the MDB's can play a greater role in improving the agricultural and environment research which is so urgently needed if development is to be economically and environmentally sustainable.

We are fortunate today in having with us two very distinguished Latin American experts who will share with us their views of what is happening in their countries. I am particularly grateful to them for coming this long distance and we are looking forward to hearing their testimony this morning.

As a preliminary to their—yes. The first witness who will a little bit later give testimony, and who will introduce a remarkable motion picture that we're about to hear, will be Jose Lutzenberger, a soil scientist and one of Brazil's leading environmentalists. Mr. Lutzenberger, we are delighted to have you. We are very pleased that you are with us. Please come to the witness table and make your opening remarks, and then, as we see the film, perhaps you would stay there and comment from time to time to all of us on anything that seems appropriate and interesting that you may wish to comment on.

Before Mr. Lutzenberger testifies, we are fortunate to have a videotape of a film which—we are fortunate to have a videotape of a film which has documented the devastation of the Brazilian rain forest over the last several years, entitled "Decade of Destruction." The film has been shown on television all over the world, but today's showing marks the first time it has been shown in this country. I am told it may be shown on public television in the weeks to come.

Today we will see some excerpts from the 4-hour documentary which have been roughly edited to meet our time requirements. Of course, in the edited version which we will see—the edited version which we will see will necessarily lose some of its continuity and

may be somewhat jumpy, but it will still give us a great sense of the devastating, pitiful, and shameful impacts of deforestation.

I would like to thank the director of the film, Mr. Adrian Cowell, and the Central Independent Television for making the film available to the subcommittee.

We will now see the film and then we'll hear from Mr. Lutzenberger. Mr. Lutzenberger, please feel free—make sure the mike is working. Just say hello. Say hello.

Mr. LUTZENBERGER. Hello.

Mr. SCHEUER. Yeah. Please feel free to make any comments you wish as the film goes on.

[Videotape presentation.]

[The printed text of the film follows:]

"THE DECADE OF DESTRUCTION"

CENTRAL
TELEVISION
AND
UNIVERSIDADE CATOLICA
DE GOIAS
MARIO ARRUDA
VICENTE RIOS
PRODUCTION

PRODUCED
BY
ROGER JAMES

DIRECTED
BY
ADRIAN COWELL

RUNNING TIME 60 MINUTES

SCRIPT MADE FROM VIDEO CASSETTE

ALL INSERTS REFER TO FOREIGN DIALOGUE

Dialogue Continuity Script made by Phoenix Scripts Limited.
March 1984

"THE DECADE OF DESTRUCTION" EPISODE 2, PAGE 1

M.T. 1: THE DECADE OF DESTRUCTION

M.T. 2: Commentary by ADRIAN COWELL

M.T. 3: 2.THE BLAZING OF THE TRAIL

NARRATOR: V/OVER In the heart of the Amazonian Forest, the great change begins like this. This road is officially known as Rondonia, four, two, nine, and we will film for two years, as it transforms a vast forest into farm land. As the rainy season of nineteen eighty one began, the bulldozers were halfway across the jungle.

NARRATOR: V/OVER At the same time another confrontation was developing, only sixty kilometres away, as hundreds of poor colonists moved up the road into the forest. This is Renato, we would follow him and his neighbours for two years. Batano was one of the neighbours.

INSERT 27: Is life better here than in Mato Grosso?

INSERT 28: I won't leave here

INSERT 29: Why?

INSERT 30: In Mato Grosso I was poor....

INSERT 31: ...had nothing, worked for others

INSERT 32: So I got this land

INSERT 33: Despite sickness...

INSERT 34: ...despite the Indians, who are dangerous...

INSERT 35: ...it's still better here than there

INSERT 36: It's a great improvement

INSERT 37: Why?

INSERT 38: Here, one works for one's self...

INSERT 39: ...plant today, to eat tomorrow

INSERT 40: On the land of others, you can't do that

INSERT 41: I believe life here will be much better than there

INSERT 42: There you worked even harder

INSERT 43: Things were more difficult

Renato and Maria were burning six hectares for their coffee and another twenty for neighbours. For six months everything had led to this one irreversible act.

NARRATOR: V/OVER In the month of September, a hot blustering wind blew across the western part of the Amazon basin and the earth, from what was once the forest floor, was sucked up as a fine yellow dust. The dust from the trucks mixed with the smoke from the trees and the worlds greatest forest just seemed to fade away. But our aim was to record environmental change in the practical terms of the people of the frontier. And for the settler the time of smog is the time of planting. It's the start of his Cafezal.

INSERT 91: - How much coffee did you plant?
- 2,200 seedlings

INSERT 92: Did you try anything else?

INSERT 93: Corn, pumpkin, melon...nothing grew

INSERT 94: let's see how the coffee does

INSERT 95: But it looks terrible

INSERT 96: The land's not good
Nothing grows

INSERT 97: But let's see this year

NARRATOR: V/OVER Even at this early stage Renato's family seeded headed for disaster.

INSERT 107: Renato, was your corn
from a seed merchant?

INSERT 108: It was from around here...

INSERT 109: ...poor seed, without pesticide

INSERT 110: But it germinated well

INSERT 111: The problem is soil deficiency.
It's very poor

INSERT 112: Dig a hole, so we can see

NARRATOR: V/OVER He's an agronomist from Ouro Preto.

INSERT 113: - Hopeless soil, no?
- Very sandy

INSERT 114: Soil with so much sand is dry

INSERT 115: It holds less water than
soil with more clay

NARRATOR: V/OVER The rains of nineteen eighty two made the Rondonia four two nine road impassable, and like many colonists Renato abandoned the land that he had hoped to keep forever. After a whole year the coffee bushes were still minute, in comparison with those where the family now worked, as share croppers, but on better soil fifty kilometres away.

INSERT 149: Renato, why did you abandon your land?

INSERT 150: It didn't produce

INSERT 151: I planted corn...

INSERT 152: ...it came out tiny

INSERT 153: Rice...

INSERT 154: ...good land gives a big sheaf. There, minute

INSERT 155: Plant 40 litres...

INSERT 156: ...harvest 3 or 4 sacks

INSERT 157: It was impossible to stay

INSERT 158: How are things here?

INSERT 159: I'm back to 50/50 sharecropping

INSERT 160: No future. Just 50/50

INSERT 161: ...as I did in Mato Grosso

INSERT 162: ...but worse, because facilities here are much worse

NARRATOR: V/OVER Renato's problem was that there was no more good land. As the official map shows all land within eighty kilometres of the highway had already been allocated.

NARRATOR: V/OVER To do this we will visit the foot of the projected road, that will soon cross the jungle. Here we can find all three types of colonization. The latest project for small colonists, an earlier type of colonization and a large ranch of thirty thousand hectares. From the air you can see the huge block the ranch has carved out of the jungle. But from the ground you can also see how the jungle fights back. It's re-seeding itself with pioneer scrub, that looks green, but is useless as fodder. Eventually this will bring back some form of forest. But for cattle it's like a green desert. The cost of weeding, according to the manager, is greater than the possible income.

INSERT 16: When did this enterprise start?

INSERT 17: It was opened up 7 years ago

INSERT 18: The jungle here was cleared 6 years ago

IMSERT 19: You've been fighting off the scrub for 6 years?

INSERT 20: That's the reason for this operation we call scraping

INSERT 21: It's why the soil's relatively impoverished

INSERT 22: Compacted soil, because of annual burning

INSERT 23: The area's been systematically burnt

INSERT 24: to recuperate what here goes by the name of pasture

INSERT 25: It's a technique I don't agree with

INSERT 26: But it's the only way we've found to defeat the scrub, a little

JOSE: V/OVER In charge of the cattle the ranch had a qualified vet.

INSERT 27: Do you have productivity figures of animals per hectare?

INSERT 28: On this ranch we work on 2-3 head per hectare

INSERT 29: But does it decline?

INSERT 30: Yes, on pasture grazed for 5-6 years

INSERT 31: the decline is very great

INSERT 32: very great

JOSE: V/OFF What we are seeing here is one of the great follies that are being committed in this country in the name of progress. Growing cattle in the Amazon jungle area is perhaps the most

stupid thing that could ever be done in this area. Extensive cattle growing means er, producing only a few dozen kilos of meat per hectare per year, and this is not even sustainable. As the manager of this farm er, conceded production goes down every year.

NARRATOR: V/OVER The government learnt from its mistake and a few years ago stopped subsidizing cattle ranches. So across the road they divided the land into fifty hectare plots for smallholders. We deliberately chose a plot with the best soil owned by an experienced farmer, from a colonist family in Rio Grande do Sul.

INSERT 33: So this is the second time in your life you've cleared a forest?

INSERT 34: Yes, the second time

INSERT 35: The first time was Parana?

INSERT 36: Yes

INSERT 37: Where?

INSERT 38: The municipality of Cascavel

INSERT 39: How long were you there?

INSERT 40: 14 years

INSERT 41: Why did you leave?

INSERT 42: The land was getting exhausted

INSERT 43: Could this land also become exhausted?

INSERT 44: It's possible

JOSE: V/OVER His first rice crop had a good yield. But if he exhausted his land in the temperate zone, here, under the strong sun and rain of the tropics, exhaustion will come much quicker. Even if he could afford conventional fertilizers, they are not suited to most Amazonian soils. So he knows he will only get yields like this by cutting more of the forest and when his whole plot is cleared he will probably move on again.

NARRATOR: V/OVER Rondonia's soils vary immensely from place to place. Just a few plots from the good soil of the last farmer we found a family, barely surviving, on a meagre corn crop. Their soil was virtual sand and the colonist and his family seemed on the edge of starvation. It's ironic, but to plant this corn he cut down some Brazil nut trees.

JOSE: V/OFF This fantastic tree trunk is

thirty metres long. It belonged to a tree, a Brazil nut tree, that was at least forty metres tall. While this tree was alive it produced at least a ton of food every year. More food than this plantation is now producing. In fact, as you can see,

this is a sick crop on a leached out soil, even one year after deforestation. If you let it, the forest can feed you, but if you fight it it can become so barren that this soil doesn't even have weeds. It's difficult to understand how the Land Agency could give away such soil, or why the colonists should go on clearing it.

V/OFF But there is no loving care for this landscape. There is no trace of awe and reverence for this marvellous ecosystem... the tropical rain forest, which is the result of millions of years of patient and irreversible organic evolution. A technology infinitely more sophisticated than anything that man can ever conceive. In fact, the only methods of dealing with the land are the methods

JOSE (CTD): V/OFF of pillage and of devastation.

NARRATOR: V/OVER In Amazonia most of the nutrients are in the trees, not in the soil. When the trees are reduced to ash, which is then washed away by the rain, what is wasted is an irreplaceable capital. But the head of the Land Agency would not agree that this sort of agriculture was unsustainable.

INSERT 72: We're replacing something sustainable that can last forever

INSERT 73: with something that can't last 20 years

INSERT 74: This is a crime

INSERT 75: In reply, we're giving food to a family

INSERT 76: For how long?

INSERT 77: For how long? I don't ask that question

INSERT 78: At least they're eating today

INSERT 79: A human being receiving food

INSERT 80: But for how long?

INSERT 81: Let's work together, so it will last

INSERT 82: I'm sacrificing one thing for another which will produce

INSERT 83: If this land should become unproductive then it's a crime

INSERT 84: A crime

Mr. LUTZENBERGER. It is interesting to note there is no attempt to even use the wood that is being destroyed, the lumber. No use whatever.

Mr. SCHEUER. All right, Mr. Lutzenberger, we would be very happy to hear your statement.

STATEMENT OF JOSE LUTZENBERGER, AGRONOMIST, ON BEHALF OF ASSOCIACAO GAUCHA DE PROTECAO AO AMBIENTE NATURAL [AGAPAN]

Mr. LUTZENBERGER. Mr. Chairman. Well, on behalf of the Brazilian environmental movement, I want to thank Chairman Scheuer for his wisdom in having decided to invite Brazilian ecologists and scientists doing research in the forest in Brazil to testify here in Congress. I hope that this will contribute to important changes while there is still time, while much of what now seems doomed to irreversable loss can still be saved.

As you have said yourself in your initial remarks, the Amazon rain forest is the last, still more or less intact and contiguous great ecosystem—actually it's a biome, one of the super ecosystems in the world—that is still more or less intact. But it is being destroyed at a rate that, if it continues unabated, and exponential as it is today, will mean its total destruction within the next 20 or 30 years. And we must do something about it.

The consequences will be extremely serious for the world at large, for world resources. There will be a loss of very precious cultures, too, and it will certainly affect cultures, the culture of the Indians, for instance, very precious cultures. And it will certainly have a very deleterious effect on world climate which will be felt probably much more seriously in the temperate and subtropical zones than it will be felt in the tropics themselves.

The American Congress has the power to contribute to the necessary changes, since you hold the strings to the World Bank funding, which the World Bank is contributing, perhaps inadvertently, to some of the destruction that is going on in the Amazon. The World Bank is financing a project, the Polonoroeste project, the Northwest Pole project, a project of $1.6 billion, which means constructing a central highway and feeder roads and setting up the infrastructure for settlers in the State of Rondonia, which is the westernmost State of Brazilian Amazonia, a territory about the size of Great Britain or of West Germany, 250,000——

Mr. SCHEUER. The state of what?

Mr. LUTZENBERGER. Rondonia, R-o-n-d-o-n-i-a.

Mr. SCHEUER. What is the project called?

Mr. LUTZENBERGER. Polonoroeste, Northwest Pole, the Northwest Pole project.

Thirty percent of this project, some 440 million, I think, dollars, is footed by the World Bank, out of a total of $1.6 billion. The ostensible aim of this project is supposed to be humanitarian. It is supposed to help poor migrants, poor peasants from other parts of Brazil, to settle in the jungles of Rondonia and become farmers there.

INCRA, the Brazilian land agency, publishes full-page ads in Brazilian magazines showing aerial views of the forest being

cleared by small settlers. And the caption says, "We are making the largest land reform in the world."

But, the settlements in Rondonia are being promoted exactly in order not to have to face social justice in other parts of Brazil, in the areas where these settlers come from, in the northeast, where large landowners have always dedicated all agricultural land to the production of sugar cane, for the export of sugar, and more recently for the production of fuel alcohol, where the powerful have always prevented autonomous peasant culture, from developing, where today, because of this situation, we have tremendous misery, famine, and even starvation.

And in the south, in the region where I live, in Rio Grande do Sul, Santa Catarina, and Parana, where we had a relatively healthy, sustainable, a peasant culture that was developed in the last 100 years and flowered into the fifties of this century, where the German, Italian, and Polish immigrants went in the last century. Well, in the south we had a relatively healthy, sustainable peasant culture, which is now almost gone, which is giving place to enormous cash crop monocultures of soybeans, mostly for export, not to feed Brazilians but to feed cows in the Common Market in Europe, cows that feed the butter mountain in a system that is so senseless that it spends billions of dollars, something like $10 or $20 billion a year to destroy food, so we destroy our last forests in the south of Brazil, in the Uruguay basin and in others to produce food for cows in Europe instead of food for people in Brazil. This is, of course, contributing to the tremendous uprooting of people, and it is the people who are being uprooted by modern export cash crops in the south and by traditional land ownership in the northeast, who are being taken to the northeast.

In fact, INCRA, the land agency, is actively promoting this migration. They are making advertisements on TV in prime time all over Brazil, enticing people to go there. So it is just the other way around. They want to take pressure off those areas where they do not want to face social justice, where they do not want to face real agrarian reform.

I will leave for you a brochure brought out by the—actually it's a photocopy of a brochure by INCRA, the land agency, where you can see how they actively promote migration to the Amazon.

The Brazilian Government, for the last 30 years, has had agricultural policies that went against the small farmer and helped only the big, the cash crop monocultures, all over the country, and more recently this trend has been incremented with our alcohol program which is destroying many of the remaining peasant cultures, even the few ones that still existed in the northeast.

So what is being done by Polonoroeste and Rondonia is only to take away pressure from the other areas of Brazil, where pressure is now building up because of concentration of land in fewer and fewer hands.

In the south we could be making permanently sustainable agriculture. And what is happening up in the north is, as you have seen from this film, disastrous.

The Government says that it wants to increase production and help the poor, but these projects are, first, uprooting the local population. The forest was not empty of people. First there are the In-

dians. The Indians are being pitilessly destroyed, if not physically, then at least culturally. We are destroying cultures that are the result of tens of thousands of years of living in harmony with the forest. We are destroying them before we even know them, before we even know—before we can even learn with them. Actually, there is an awful lot we can learn from the Indians. The Indians are the only real ecologists who know how to handle the forest, who know how to live in harmony with it. They have lived in those forests for at least 30,000 years. But we are destroying those cultures even before we have a chance of registering their wisdom.

But not only the Indians live in the forest. After the Indian comes the caboclos. The caboclos is the halfbreed usually of European and Indian, sometimes Negro stock, who is the real successor of the Indian. He may not have the wisdom, the ecological and philosophical wisdom that the Indian had, but he has learned to live in harmony with the forest. He makes only very small clearings, clearings that are like pin pricks in the immensity of the forest, that are perfectly compatible with the survival of the forest, and he lives off of tropical fruit, off fishing and hunting.

As you have seen in the film, when the forest is destroyed to make large cattle farms, and even where they do not set up large cattle farms in the first place, much of what happens—much of the colonization schemes, where they put the small farmers after they give up the land is then bought up by large outfits that will put it to cattle, too. On the cattle farms production is ridiculously low. It is of the order of several dozen kilos of meat per hectare per year, most of the time not much more than 30 or 40, maybe 50 kilos a hectare, which is about one-tenth of what is produced on farms in Europe or here in the United States. So it is ridiculously low production and, in fact, the caboclos very wisely used to say, "where cattle comes, we have to go because we will starve."

And those farms don't even provide much labor, much employment. They use 1 or 2 men for 2,000 or 3,000 cattle. So they actually contribute to emptying the forest of its people. Those forests were not empty. This is the case in most tropical forests in the world. We always forget the local population. And on top of the caboclos we also have the seringeuiros. The seringeuiros is the rubber tapper, the rubber tapper that lives from the forest without destroying it. Brazil today imports two-thirds of its rubber production, of its natural rubber—of its natural rubber needs—when, in fact, it could be producing rubber for export. We could very easily help the rubber tapper to increase his production by planting more rubber trees in the forest.

Mr. SCHEUER. I take it the rubber culture in the forest could be so designed that it would be in harmony——

Mr. LUTZENBERGER. Yes.

Mr. SCHEUER [continuing]. With the development of the forest, qua forest——

Mr. LUTZENBERGER. Exactly.

Mr. SCHEUER [continuing]. As a rain forest.

Mr. LUTZENBERGER. There are a few private schemes, one in Costa Marcus, where the forest was enriched with rubber trees, so that the rubber tapper who normally walks 30 or 40 kilometers a day to collect his rubber can do it on 10 kilometers. When you

plant rubber trees in the forests, you need no fertilizer, no pesticides. On the other hand, the monocultures that are now being set up are extremely vulnerable to pests, they use all kinds of so-called modern inputs; they start by using heavy doses of chemical fertilizer and then herbicides and fungicides and insecticides and all that, and they seem to be totally unsustainable. Actually, we have had other experiments like the Ford experiment in the thirties which were a total failure.

The interesting thing is that even in the few cases where the settlers, out of their own wisdom, decide to make something closer to nature, where instead of planting monocultures of rubber trees only they make mixed stands of rubber trees with citrus, with coffee, with cocoa, which works much better and where they do not have pest problems.

The development policies of the Government are set up in such a way that they cannot do this. When a farmer makes mixed stands of the different cultures, thereby combining the advantages of mixed stands and of monoculture by planting monocultures in rows and mixed across the rows, the agencies for the different cash crops, such as the rubber agency or the citrus agency or the coffee agency or the cocoa agency, each one insists that he go back to monoculture. Otherwise, he gets no credit. So it looks as if the whole system was set up for maximum destruction, not for maximum production and sustainability and social justice.

Mr. SCHEUER. Let me ask, you mentioned the Ford investment. Was that by the Ford Foundation?

Mr. LUTZENBERGER. By the Ford—no, by the Ford Co.

Mr. SCHEUER. The Ford Co.

Have there been any recent experiments in mixed development, in multiuse or multipurpose developments, either by our Government or by any of the great foundations or the agricultural colleges or whatever, that would combine modern inputs and modern technology and modern knowledge of agricultural techniques and new plants and new fertilizers and pesticides, combined that with the concept of living with the forest, perhaps on a smaller scale, to integrate these developments with the continued survival of the tropical forest? Have we ever—do we have any experience of that kind to guide us and to show a possible alternative to the large-scale destruction of the forest that you have outlined and that that movie so graphically demonstrated?

Mr. LUTZENBERGER. Well, I know of some research that is going on at the Amazon Research Institute in Manaos, the IMPA, Instituto Macionale de Pesquisa Amazonia, where they are trying permaculture, mixed stands of tree, crops, such as jack tree, fruit tree and many palm trees, and they are showing that you can produce up to 10 times more food per hectare with tree crops, standing crops, permanent crops, that are perfectly sustainable, and that need no modern inputs. They need practically no inputs because you have no pests under those conditions, and you don't need fertilizer. Fertilization is organic, as it always was in the forest——

Mr. SCHEUER. Has this ever been presented as a possible project to the World Bank for funding?

Mr. LUTZENBERGER. Well, I don't know whether it was presented to them, but we would like the World Bank to look into this. As far

as I know, no interest was ever shown by our Government in this kind of research because they are not interested in helping the inhabitants of the forest. They are not interested in helping the caboclos, in helping the rubber tapper, and they are not interested in having the Indian survive. They are interested in big plantations and technocratic structures.

Mr. SCHEUER. When you say they, who are you speaking of?

Mr. LUTZENBERGER. The Government, our Government.

Mr. SCHEUER. Our Government or the Brazilian Government?

Mr. LUTZENBERGER. The Brazilian Government.

Mr. SCHEUER. The Brazilian Government.

Mr. LUTZENBERGER. The Brazilian Government.

Mr. SCHEUER. Yes.

Mr. LUTZENBERGER. And, of course, the World Bank probably talks only to our Government. They have not yet listened to Brazilian environmentalists and to Brazilian anthopologists and to scientists that I know who are proposing this kind of research and this kind of development.

Mr. SCHEUER. You know, this appears to me as much of a population problem as it is an environment problem, because it seems to me that much of the drive for this kind of project is because of Brazil's galloping population expansion. It's—I'm particularly interested in this matter because I'm chairman of the board of a global committee of parliamentarians on population development.

Do you know Geraldo Sanford?

Mr. LUTZENBERGER. No.

Mr. SCHEUER. He's a Brazilian parliamentarian who plays quite a leadership role in this global group.

And due to the efforts of Brazilian parliamentarians and others, Brazil, as you know, has abandoned its pronatalist official policy and now they have turned around 180 degrees, along with Mexico, so that the two largest countries in Latin America now are actively engaged in helping their people control their fertility and helping young couples achieve a new sense of family-size goals that are more compatible with their own happiness and with the well-being of the country.

It might be that this $1.6 billion that the World Bank is helping to finance might better be spent in funding a proliferating network of family planning clinics and educational programs of all kinds on television and in the press on family planning, as perhaps a far better long-term solution to their burgeoning population problem than trying—than this apparent attempt to destroy the Amazon Basin——

Mr. LUTZENBERGER. Of course.

Mr. SCHEUER [continuing]. To take care of their expanding population that way.

We have a number of witnesses remaining this morning. We have been fascinated by the movie and even more fascinated by your comments. Would you like to say a couple of words to sum up—and let me say——

Mr. LUTZENBERGER. Yes.

Mr. SCHEUER [continuing]. That your prepared testimony will be printed in full in the record just prior to——

Mr. LUTZENBERGER. Good.

Mr. SCHEUER [continuing]. Your oral testimony, so that all your views will be amply included in the record.

Why don't you——

Mr. LUTZENBERGER. Well, I would like——

Mr. SCHEUER. Why don't you sum up for a moment or two.

I would like you—I mean Congress here—to know that the World Bank has written conditions into its agreements—for instance, the respective Indian reserves and not making colonization schemes in areas with unsuitable soils. And these agreements are being flouted by our Government. They are being blatantly flouted. So actually the World Bank should now cease its funding for this project. It would then also be sending a very important sign—signal—for further development of the Amazon.

I would very much like to see the World Bank and other institutions go into alternative research, research which in part is already being done, as I mentioned, into sustainable ways of using not only the forest but especially the soils and the landscapes in the areas where these migrants come from.

It is true that we have a population explosion problem, but Brazil is enormous. It is as large as the Continental United States, 8.5 million square kilometers, and we do not yet have real problems of population pressure. What we have are problems of distribution of wealth, distribution of land. And we could even bring all those migrants back to the south. In the south, in Rio Grande do Sul, in Santa Catarina, in the state of Parana, we have exceptionally good and fertile soils, very deep soils, that even after you lose 1 or 2 feet to erosion, you can still recover them, and you can recover them with locally obtainable inputs. We don't have to spend $3 billion a year importing chemical fertilizers and pesticides, increasing our debt that we cannot pay already. We already do not earn on exports the necessary money to pay even the interest on that.

So what we really need is research in preserving our good soils in the south, of making a healthy type of agriculture in the south, and also now we need research in the Amazon on how to recover the soils that were already degraded. Millions of hectares, not only in Rondonia but in other areas of the Amazon, have been destroyed and they must be recovered in some way. This is a tremendously important job that we face now. I sure wish the World Bank could help us on that.

[The prepared statement of Mr. Lutzenberger follows:]

TESTIMONY BY BRAZILIAN AGRONOMIST, JOSE LUTZENBERGER,
ON BEHALF OF
ASSOCIACAO GAUCHA DE PROTECAO AO AMBIENTE NATURAL (AGAPAN)
BEFORE THE
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND
ENVIRONMENT OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
September 19, 1984

I have been asked to talk about the development programme in Western Amazonia called the Polonoreste Project, which is partly funded by the World Bank. This is a $1.6 billion project, of which the Bank's share is $443 million. The main part of the loan is for a central highway and the rest is for feeder roads and the infrastructure for planting settlers in the forest. I will begin by describing very briefly its content--the social policy behind it.

Many development projects are publicized as dealing with great economic and social problems like famine, disease, lack of good water, and the Polonoreste scheme is often projected as dealing with a similar sort of problem -- the westward migration of Brazil's agricultural poor. What is seldom pointed out is that, unlike famine or disease, the migration into Amazonia is deliberately promoted and encouraged by our government. INCRA, our land agency, has been -- and is at the moment -- putting paid advertisements on television, enticing farmers from other parts of Brazil to go to Rondonia. Some of their newspaper and magazine advertisements show aerial views of primeval forest with captions saying, "We are making the largest agricultural reform in the world." But the settlement schemes are conceived

precisely in order not to have to face social justice in other parts of Brazil, in order not to carry out agrarian reform and to change agricultural policies in other regions. I would now like to submit for the record a publicity brochure of the Rondonia State Government encouraging migration to Rondonia which says, "Good land, appropriate land ... these lands offer excellent possibilities for the expansion of agricultural productivity."

In considering the Polonoreste project, it is important to be aware that the principal social and political objective is to transfer our agricultural poor -- mainly from the northeast and south of Brazil -- to the Amazon. The largest block of migrants come from the South where I live. It is a region of good soil, originally settled by German, Italian and Polish immigrants, and it produced a relatively healthy, permanently sustainable peasant agriculture in the last century which flowered into the fifties of this century. It is now in total decline. Government policies for the last 30 years have deliberately gone against the interests of the peasants. The government has promoted only cash crops, monoculture for export, especially soybean plantations. It also promoted "modern inputs": heavy and sophisticated machinery, synthetic-mineral fertilizers, and pesticides. In ~~some~~ many cases huge estates have bought up the small holdings and enormous soybean plantations were set up, some of them thousands of hectares.

It is calculated that there are at least 2,500,000 landless poor in Brazil today, and the Polonoreste project is

designed as a safety valve for the political and social pressures caused by them. There is in fact no shortage of land in the South except the shortages created by the concentrations of land holdings. The Polonoreste project is a method of decreasing the risks and increasing the security of the large landowners. And it does this by removing some of the rural poor from the regions where they were born and dumping them in the Amazon. What's worse, it transfers them from rich soils, in a subtropical climate, which can recuperate relatively quickly, to poor tropical soil where deforestation does permanent damage.

This is the social and agricultural context of the Polonoreste project, which is 30% funded by the World Bank. The project's stated aim is "to ensure growth of production in harmony with preoccupation for the preservation of ecosystems and natural resources." The exact opposite is happening. Devastation of the forest in Rondonia is uncontrolled, production is not being secured in the settlements.

It seems paradoxical, but the soils under the lush tropical rain forest are the poorest in the world. Permanently high temperatures and high rainfall leach away all the mineral nutrients. The clay fraction of the soil, where there is one, is also degraded to the point where it can hold almost no mineral nutrients. Therefore, the rain forest holds all its nutrients in its biomass. When the forest is cut down and burnt, and the heavy downpours wash away the ashes, most of the nutrient capital of the forest is gone. The rivers take it to the ocean. Since the soil has no holding capacity, conventional fertilizers are of little use, and high transportation costs also make them too expensive.

As can be seen in our film, the land is cut up by straight roads and is divided by our land agency--INCRA, according to checkerboard-like patterns blindly conceived on the drawing board. Some plots are on relatively good soil, others are on almost pure sand or on rock outcroppings. Some are totally or partially on slopes too steep to plow, thus guaranteeing erosion from the start. Others may be totally flat or rolling. One plot may cut across the meanders of the same brook several times, thus forcing the farmers to build several bridges. Another plot may have access to no water at all. This is a bad way to treat any terrain, but for tropical forests with its fragile soils it can be disastrous.

It is quite common to see settlers give up their clearings after the first meager harvest. They have to make new clearings every year. Then, when the whole plot is cleared, they move on again. The Polonoreste project has only been operating for a few years, but there are already examples in Rondonia where entrepreneurs have bought up half a dozen or a dozen plots, so the process of the concentration of agriculture and the building up of big estates, which drove the poor off the land in the South and Northeast, is already beginning in Rondonia. In many cases, the farmers are grandsons of colonists who cleared the forest in my home state of Rio Grande do Sul. A second wave moved on to clear the great forests in Paraná in the 1950s. Now the same is happening in Rondonia.

In addition, because cattle is the simplest method of holding land with a small labor force, the plots that are bought up

are usually turned into poor pasture. The productivity of extensive cattle-raising on these pastures is ridiculously low -- 30 to 60 kg per hectare per year, as compared to 10 times that much in temperate climates. The forest itself, before it was cut down, produced much more food per hectare in the form of tropical fruit, of game, and the fish life it sustained in the streams.

(I will not go into a more detailed discussion of what is wrong with the agricultural policy in Rondonia because some of this was shown in the film we've seen, and because it will be dealt with in some of the testimonies that follow.) A particularly sad aspect of what is happening in Rondonia is that ecological and social damage always go together. The forests that the settlers are cutting down are not empty. The humans already living in them, Indians, rubber tappers and caboclos -- our word for jungle dweller -- have an interest in the preservation of the forest. And the destruction of the forest uproots the only people who have learned to live in relative harmony with it.

The Indians are pitilessly destroyed culturally, when not physically. And yet there is so much we could learn from them. Their knowledge of the ecology of the forest, their skills in knowing how to use it are lost even before we can register them. The loss of these cultures is just as irreversible as the loss of a species. A species is the result of millions of years of irreversible organic evolution. An indigenous culture is the result of thousands of years of living in harmony with the ecosystem.

The caboclos -- they are usually of mixed stock, Indian, and white -- are the natural successors of the Indians. They live in the forest, surviving on shifting agriculture and as hunters-gatherers. Their lifestyle is quite compatible with the survival of the forest as long as their population doesn't increase too much. Their small clearings have cassava, some fruit trees, a few chickens or pigs, sometimes a cow, only to complement the diet they take out of the forest, tropical fruit, game, and fish. At the present population density they do not overexploit. Fish and game survive. (If they were left alone, there would be plenty of time for the working out of methods of dealing with the forest on a level of more intensive, but sustainable productivity.)

Finally, there is the seringueiro, or rubber tapper, who bleeds rubber from the wild rubber trees in the jungle. He has an income equal or superior to that of the metal worker in the automobile industry in Sao Paulo. And he has almost no expenses, because most of his food is free. It comes from the forest and his small crops. During the last world war the Central Government, which then called the seringueiro "o soldado da borracha" (the soldier of rubber) promised him title to the land on which he worked. This would have been very easy to implement. Each seringueiro needs no more than 200-500 ha. Of course, the promise was seldom fulfilled. We know of only one program where some tappers were given 250 ha. In general, when they are displaced by colonization projects they get no more than 25 ha. Invariably, they sell the land and end up in slums or as day laborers.

Why can't we leave Amazonia to the Amazonians? Indians, caboclos, seringeuiros are compatible with the survival of the forest. Their lifestyle could easily be improved socially and ecologically by teaching them better cropping and collecting or fishing methods, storage methods, and hygiene. But almost nothing is being done in that direction. The reason, of course, is that there is no advantage to be gained from leaving these people in the jungle, while there are immense political advantages to be gained from transferring the agricultural poor from the South and Northeast of Brazil to Amazonia.

On behalf of the Brazilian environmental movement, and on behalf of many cooperating citizen groups, I ask whether the World Bank should be providing 30% of the money for a project which:

1. makes it easier and socially safer for the powerful to maintain huge estates in the Northeast and to promote cash crop monocultures for export in the South.
2. substitutes unsuitable forms of agriculture for the tropical forest.
3. and which drives out of the forest the only people who have developed a sustainable way of using it.

If the World Bank wishes to help us with our problems, why does it not invest more in projects which help fix the agricultural poor on their own lands in the South and Northeast? And why does it not invest in research to improve the economy of the caboclos and seringueiros who already live in the forest?

Some very interesting research along that line is being done at INPA -- the Amazonian Research Institute. Researchers there are showing that permaculture -- trees such as breadfruit, jackfruit, and many other tropical fruit trees, coconut and numerous native palm trees can produce up to 10 times as much energy and protein per ha with less work, no new clearings, than can the traditional crops.

The life of the rubber tapper could also be made much easier and more productive by increasing the density of rubber trees in the forest. This requires no fertilizer, no herbicides, and the forest is not felled. There are a few successful examples of this type of work, mainly due to private initiative, but the government shows no interest in them. At present, Brazil imports two-thirds of its natural rubber needs. But by increasing the density of the trees we could easily have enough natural rubber to export.

What really needs to be done is not being done. In the Amazon we now need research on how to recuperate the soils already degraded, on how to do that with locally obtainable resources, organic soil management, insoluble mineral nutrients obtained from regional rocks or with raw phosphate from the Northeast. We must also set up schemes to protect the remaining Indian cultures and to help the already existing population. Not a single hectare of remaining forest need be cleared if we really decided to tackle these staggering problems. Why not finance this kind of meaningful work?

In the South, we must save our fertile soils, that could feed us and that can help feed the world, if we learn how to handle them on a sustainable basis. There is, in fact, no shortage of land in Brazil, but today's levels of productivity are extremely low and they are bought at the expense of future productivity.. These soils respond extremely well to organic management. Productivity then goes up steeply and erosion goes down, so do pests and diseases.

In the Northeast, in Central Brazil, in the South, we face tremendous tasks, and Brazil has enough space to allow the big and the small to live side by side.

We have a formidable job before us. If we learn to handle it we can bring back all the stranded migrants. Perhaps the World Bank can help us with a really rational job, instead of helping our government help the landlords who are strong enough to help themselves.

Finally, I would like to ask why the World Bank bothers to write conditions into its loan agreements, and then does nothing when those conditions are blatantly flouted -- such as the clauses about Indian reserves, virtually none of which have been demarcated in the Polonoreste region.

In the case of the more environmental conditions, it is obviously impossible to reverse the type of destruction already carried out in Rondonia. But at present, the last large area of untouched forest -- the Guaporé Valley -- is about to be opened up by the BR 429 road. According to Rondonia's Ministry of Transportation, the last 100 km of road should be through in November. And yet this road blatantly flouts two conditions

in the World Bank's loan agreement. In section 3.13 of the Phase I loan agreement (for the "Agricultural Development and Environmental Protection Project" -- loan number 2060 BR) it is agreed: "To discourage the agricultural exploitation of areas which have been determined to be unsuitable for agricultural development or of areas whose suitability for agricultural development has not yet been determined." Why, therefore, does the Bank not object to the colonization of Settlement Projects Bom Principio, Terra Firme, Conceicao, Porto Murtinho, Surpresa, Cena Grande, Sao Domingos, Monte Cristo, and Sao Miguel when the soil survey maps describe most of this soil as unsuitable for small farmer agriculture?

Secondly, the loan agreement for the first phase, Agricultural Development and Environmental Protection Project (Loan No. 2060 BR) states in section 4.05:

> "The Borrower and the Bank agree that the strengthening of the measures to protect the indigenous Amerindian population in the program area is essential to the successful carrying out of the project. To this end, the Borrower shall take all necessary measures to put into effect promptly the special project for protecting the interests of the Amerindian communities located in the program area."

In the light of that clause, how can the Bank not object to a road which is going through an area regularly hunted by unknown Indians who have killed colonists and rubber tappers in the area in 1981 and 1983. The regional head of the government Indian agency, Apoena Meirelles, confirmed this in a recent press interview when he said that all new INCRA projects should first have a Certidao Negativo (a no objection agreement) from the Indian Agency confirming that there were no Indians in the area. When he was asked if this meant that the BR 429 road was -- with reference to the Indians -- proceeding blindly, he replied, "Completely blindly."

On behalf of the environmental groups of Brazil, I call on the Bank to stop the road and re-think its policy on Rondonia.

A arrojada marcha para o Norceste
"The March for the Northwest"
Produzida por Frias Assessoria de Comunicação. Editor: Frias Netto. Colaboradores: Antonio Prates Amorim, Orestes Amorim, Reinaldo Leme (redação), José Rumjel de Farias Neto (consultoria), Roberto Castello, Manoel Nascimento, Vanderlei Menezhus (fotos), ME C. Dassie (arte e lay-out), Claudinery José Ferreira (secretaria gráfica). Capa: arte de Alberto Naddeo.

"When it will be rebuilt, highway BR-364 will be the road of progress for a region of 410,000 km²"

Quando estiver reconstruída, a BR-364 será o caminho do progresso de uma região de 410 000 km²

mento da Presidência da República, pretende, no espaço de pouco mais de uma década, mudar a face desta região do País.

O primeiro passo neste processo é a recuperação integral dos 1 500 quilômetros de estrada que ligam Cuiabá a Porto Velho. Única via de acesso e saída para a região Noroeste e principal eixo de ligação entre o Oeste e o Noroeste do Estado do Mato Grosso, a rodovia BR-364 se converteu no principal ponto de apoio ao programa — um ponto de apoio que estenderá benefícios a uma área de mais de 410 mil quilômetros quadrados e a uma população de 1,1 milhão de habitantes.

Além disso, quando pronta, a estrada fechará a malha viária de integração nacional e se tornará a principal via de ligação do Brasil com os países latino-americanos vizinhos.

O impacto na região — Em 1978, à época dos primeiros estudos sobre o fluxo de produção da região, verificou-se uma importação de 840 mil toneladas de mercadorias e uma exportação de 513 mil toneladas. E 98% destes totais foram transportados pela BR-364 em caminhões. Para se ter uma idéia do fator multiplicador que representará a recuperação da rodovia, basta dizer que, hoje, os caminhões cobrem seus 1 500 quilômetros, em média, nas épocas de seca, em cinco dias e, nos períodos de chuvas, em torno de 20 dias.

Quando a obra estiver concluída, o percurso poderá ser feito em apenas dois dias e meio de viagem, o que representará uma redução de cerca de 40% nos custos de operação do sistema de transportes. Calcula-se que o fluxo médio diário em trechos como o da cidade de Barracão Queimado a Porto Esperidião e de Porto Esperidião a Cáceres que, em 1980, registrava um movimento de 230 e 684 veículos, respectivamente, cresça, até 1989, para 1 139 e 2 924.

Apesar das dificuldades de trânsito da estrada, em 1980 entraram em Rondônia, através da cidade de Vilhena, cerca de 58 mil pessoas, contra 6 mil, em 1977.

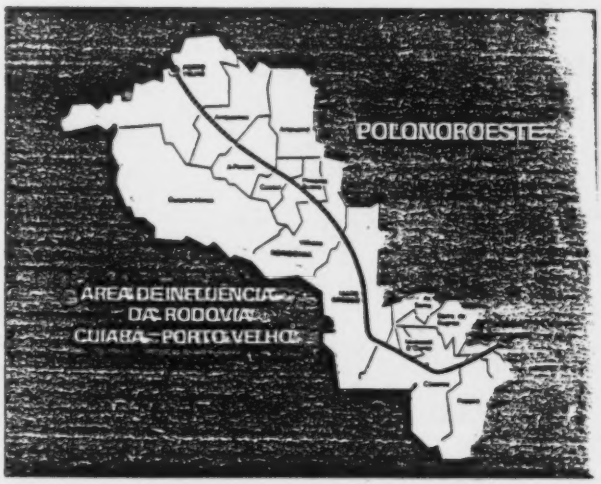
Foram estes números que levaram o governo a ampliar o compromisso de uma simples pavimentação da BR-364 para um complexo plano de desenvolvimento regional, envolvendo seis ministérios e mais de uma dezena de autarquias e órgãos públicos. Se estas medidas não fossem adotadas, um fluxo migratório descontrolado poderia causar uma pressão insuportável, com graves repercussões no plano social.

"Good land, appropriate land....these lands offer excellent possibilities for the expansion of agricultural productivity...or the growth of cattle raising."

econômico e no meio-ambiente.

Assim, verificada a necessidade de a obra rodoviária ser complementada por um conjunto de ações para o desenvolvimento equilibrado de toda a região, o governo criou, em agosto de 1979, um grupo de trabalho com a finalidade de propor um programa integrado.

O grupo produziu um relatório com a definição dos objetivos, estratégias, instrumentos de ação e valores do Polonoroeste. Esta proposta, desenvolvida a nível de ação conjunta do governo federal, com a colaboração dos governos de Mato Grosso e Rondônia, resultou nos atos básicos de constituição do Polonoroeste e de seus vários projetos.



A estratégia — A integração socio-econômica da região-programa ao resto do País será realizada através de um conjunto de medidas enfeixadas em três projetos na área de transportes: a reconstrução e pavimentação da rodovia Cuiabá—Porto Velho, a construção e manutenção de estradas vicinais e o fortalecimento do Departamento de Estradas de Rodagem de Rondônia.

A ocupação ordenada da região, com o estabelecimento de condições para facilitar o acesso à terra e garantir o emprego de forma permanente no meio rural, deverá ser alcançada sobretudo através de projetos de colonização de novas áreas em Mato Grosso e Rondônia e de regularização fundiária — este último, particularmente em Mato Grosso, onde são mais intensos os problemas em relação à posse da terra.

Já os objetivos de incremento à produção da região e de elevação da renda da população que, deverão reduzir as diferenças inter e intra-regionais, serão alcançados através da implantação dos projetos de desenvolvimento rural integrado de Rondônia e de Mato Grosso.

Finalmente, as preocupações com a preservação do meio-ambiente e das comunidades indígenas serão resolvidas através de planos que visam preservar o equilíbrio ecológico e proteger a população indígena.

Terra boa, terra própria — A região onde se localiza o Polonoroeste abrange praticamente a quase totalidade do novo Estado de Rondônia (243 044 km²) e parte do Mato Grosso (167 114 km²), ou seja, uma área de 410 mil quilômetros quadrados, dos quais 250 mil são constituídos de terra de aptidão agrícola regular ou boa. Estas terras oferecem excelentes possibilidades para uma expressiva expansão da produção agrícola — especialmente de culturas como o café, cacau, arroz, milho e o crescimento da pecuária bovina.

O fato de boa parte desta terra não estar ocupada economicamente e de ter poucos problemas de natureza fundiária, tornam a região-programa muito atraente e ideal para a fixação de uma nova população rural. Aliás, esta é uma das mais importantes caracterísiticas do Polonoroeste: um programa voltado basicamente para a fixação e acomodação daqueles que procuram melhores condições de vida, terra, emprego e apoio para os que já se encontram radicados.

É o caso, por exemplo, de seu José Severino da Silva, um pernambucano que chegou há dez anos ao Mato Grosso com mulher e um filho de colo fugindo da seca do sertão. Severino

"The epic of pioneers in search of land and work"

"Even without resources, they were arriving, disposed to conquer the jungle. And they did it."

A epopéia dos pioneiros, em busca de terra e trabalho

Mesmo sem recursos, eles foram chegando, dispostos a vencer a selva. E conseguiram

Nós viemos pra cá porque somos homens de luta, homens que querem ter um futuro. E quem tem terra tem o futuro nas mãos e pode lutar para deixar algo para os filhos". Quem diz isso é o ex-professor paranaense David Fontolan, 38 anos, casado, formado em administração de empresas, que deixou sua terra natal, a cidade de Bandeirantes, para participar da grande aventura de ocupar economicamente a selva de Rondônia.

David é mais um entre centenas de milhares de homens, mulheres e crianças que, a partir da década de 70, começaram a chegar ao então Território de Rondônia e que faziam brotar, com espantosa rapidez, cidades e vilas ao longo da BR-364. Este épico fluxo migratório era alimentado basicamente pelo chamado "telefone de boca". Os primeiros migrantes a chegar, ao retornar aos seus Estados de origem para buscar a família, divulgavam as boas novas: grandes áreas devolutas, sem dono, em solos de boa fertilidade. Era o que bastava: na volta, traziam atrás de si dezenas de amigos e conhecidos.

Raul Ribeiro e família: com o esforço conjunto, um prêmio de produtividade

Assim, em pouco tempo a região registrou um crescimento demográfico jamais visto no País. O projeto de colonização de Ouro Preto, um dos primeiros a serem criados, é um exemplo desse vertiginoso crescimento. Planejado para receber mil famílias, em apenas quatro anos já contava com quatro mil, e era forçado a estender sua área original, ao longo da rodovia, e penetrar na selva.

Terra e trabalho — Homens de toda a parte do Brasil — alguns ricos e cul-

O Governo não desiste de tentar convencer as famílias de Nova Ronda Alta a se fixarem nos projetos de colonização no Norte do país. Dia 13, último, um Wolkswagen branco, sem placas, "derramou" no acampamento dos sem terra vários exemplares da revista ao lado. Trata-se de um "Informe do Polonoroeste", projeto de colonização mantido pelo Governo Federal na área de influência da Rodovia Cuiabá-Porto Velho, nos Estados do Mato Grosso e Rondonia. Os colonos identificaram o carro e seus ocupantes, como sendo a "polícia secreta" que circula, já há algum tempo, na região de Ronda Alta. Sempre fazendo provocações.

SEM TERRA

BOLETIM INFORMATIVO DA CAMPANHA DE SOLIDARIEDADE AOS AGRICULTORES SEM TERRA

ANO II - Nº 25

Porto Alegre - primeira e segunda quinzena de julho de 1982

"The Government doesn't give up trying to convince the families of Nova Ronda Alta to move to the colonization projects in the north of the country. Last 13th of June, a white Volkswagen, without license plates, "spilled" onto the campsite of those without land various copies of the magazine pictured to the side, "Informe do Polonoroeste", describing a colonization project maintained by the Federal Government in the area of influence of the Cuiabá-Porto Velho highway, in the states of Mato Grosso and Rondônia. The colonists identified the car and its occupants as being from the "secret police" that already has been circulating for some time in the region of Ronda Alta--always making provocations."

Mr. SCHEUER. Do you have—do you plan to see the World Bank officials in Washington on this trip?

Mr. LUTZENBERGER. We are going to meet them tomorrow, I think.

Mr. SCHEUER. Very good.

Mr. LUTZENBERGER. And may I say one more thing to finish. I would really like to contribute to the awareness in the rest of the world, especially in the developed countries, in the United States. and in Europe, to a very, very serious problem; namely, the problem of climate, which I already touched at the beginning of my testimony.

What happens in the Amazon today concerns everybody on this planet, not just the people living there. If the forest really is destroyed within the next 20 or 30 years, that will have very, very serious effects on world climate. Nobody can predict what kinds of effects they will be, but they will certainly not be pleasant effects, and they will certainly affect our capacity for agricultural production, especially in those areas that today feed the world, like the United States, Europe, we down south in our——

Mr. SCHEUER. What kind of climatological phenomena will be released or will be produced by this process of destruction of the forest?

Mr. LUTZENBERGER. Well, I talked to a man who should know, a Jim Lovelock in Great Britain, who is one of the greatest ecologists concerned with world climate and models. He thinks that the deforestation of the Amazon forest will make the climate in the temperate and subtropical regions more dry. It will turn much of what is today highly productive farmland into desert. And it will, of course, contribute to very irregular climate.

We have had in the last 100 years relatively stable climate which enabled mankind to grow the way it did because we had secure, assured harvests. Once we get irregular climate—and it seems like this is already happening. Actually, I have seen remarks by important scientists who are very, very worried now. If we get irregular climate, as we seem to be having it already—in my home state we had four months of almost continuous rain this year, and north of us in the State of Paraná they had almost 5 months of continuous drought. The summer in Europe was different, and you had different climate, different conditions here, too. In my hometown in Porto Alegre we had snow a few weeks ago, something that was unheard of. We have never had snow. There is no historical record of snow falling in Porto Alegre, and we have snow suddenly. So it looks as if climate was really becoming more irregular.

Mr. SCHEUER. Do you think you could establish more or less scientifically a cause and effect relationship between the continuing destruction of the rain forest in the Amazon and this appearance of snow in September?

Mr. LUTZENBERGER. Well, climate——

Mr. SCHEUER. I don't say that critically or disparagingly. I'm genuinely probing to see what——

Mr. LUTZENBERGER. Well, the destruction of the forest is only one of the factors affecting world climate. We have many mechanisms of world climate equilibrium, among them the CO_2 balance which

is being changed by modern industrial society, by burning more and more fossil fuels, but destruction, the burning of——

Mr. SCHEUER. Of course, that brings into consideration the entire "greenhouse" effect that you're familiar with.

Mr. LUTZENBERGER. Yeah.

Then the destruction of the forests will probably contribute to very serious changes in world atmospheric circulation. Today the still more or less intact forest in the Amazon contains about 20 percent of world freshwater circulation, and the climate of the forest is more or less self-made, as we know by the studies of scientists such as Salati in Brazil; 50 percent of the rain that falls on the forest is produced by the forest itself, so the rain that falls is 50 percent reevaporated through evapotranspiration. By the time rain falls on the eastern slopes of the Andes, it is water that has gone up and down five times. But now we are destroying the forests at the beginning of this chain, at the mouth of the Amazon in the State of Pará, at a rate that will mean its total destruction within the next 10 years, an area of 1 million square kilometers.

Well, that might break up the whole chain. We don't know what effects that will have on world climate. But it will certainly affect world air circulation. So modern industrial society is tampering with all mechanisms of climate control—CO_2, O_3, dust and aerosols in the atmosphere, evapotranspiration in the case of the forest. We destroy that fantastic evapotranspiration that puts 50 percent of the rain back into the atmosphere, and in its place we get almost naked soil that makes hot, hot drafts that dissolve the clouds that would be producing rain. So we are acting like the proverbial monkeys in the cockpit of a big plane, playing with all those control mechanisms, but not knowing what they're doing, and the plane is already vibrating.

This is what's really happening. Nobody can foresee exactly what will happen. But most probably it will not be pleasant.

Mr. SCHEUER. You would like to get the monkeys out of the cockpit.

Mr. LUTZENBERGER. That's it, and a real pilot in there.

Mr. SCHEUER. Well, your testimony is enough to shake the sanest and the most stable of us all. We appreciate it very, very much, Mr. Lutzenberger.

I would like to see next year perhaps a combination of congressional committees visiting Brazil. I would like to see our Committee on Science and Technology, which has jurisdiction over atmosphere, climate, ecology, environment, and the like, plus the Interior Committee, which has jurisdiction over the environment, which is headed up by Congressman Mo Udall, one of our most distinguished Members of Congress and a man who is very devoted to the environment, and perhaps we can arrange some kind of a joint mission down there to delve into this even further.

I'm going to be talking to some World Bank officials tomorrow, too, for breakfast——

Mr. LUTZENBERGER. Very good.

Mr. SCHEUER [continuing]. And I want to talk—this is off the record.

[Discussion off the record.]

Mr. SCHEUER. We appreciate the testimony very, very much, Mr. Lutzenberger, and we appreciate your coming all this distance to, among other things, to enlighten us.

Mr. SCHEUER. We will now call Mr. Jorge Illueca, the Director of the Panamanian Environmental Commission, the Comisión Nacional del Medio Ambiente.

Why don't you remain there, Mr. Lutzenberger. It may be that when Mr. Illueca has finished his testimony you will want to have something to say.

Mr. Illueca, we are running very late. We're delighted to have you. Your full prepared text will be printed in its full form at this point in the record. So why don't you take 5 or 6 or 7 minutes to sum up your views, and refer to anything that you have heard this morning from Mr. Lutzenberger, and then I'm sure we'll have some questions for you.

STATEMENT OF JORGE E. ILLUECA, PH.D., EXECUTIVE SECRETARY, NATIONAL COMMISSION ON THE ENVIRONMENT, PRESIDENCY OF THE REPUBLIC OF PANAMA

Mr. ILLUECA. Very good.

First of all, in my capacity as Executive Secretary of the National Commission on the Environment, I would like to express my appreciation for the——

Mr. SCHEUER. The National Committee on the Environment of Panama?

Mr. ILLUECA. The National Commission on the Environment of the Republic of Panama——

Mr. SCHEUER. Very good.

Mr. ILLUECA. Which is a presidential commission.

I would like to express my appreciation for this opportunity to testify before the committee.

I feel that we are addressing some very critical problems that require solutions with urgency.

Mr. Lutzenberger has expressed most eloquently the environmental problems that Brazil, the largest Latin American country, is experiencing today. Panama, which is one of the smaller countries, unfortunately is experiencing very, very similar problems.

First of all, I would like to give some background on the Republic of Panama. The Republic of Panama lies within the neotropical zone or within the humid neotropics in an area that is characterized by a great deal of ecological diversity. The—although it is a small country of approximately 75,000 square kilometers, it is one of the richest biological regions in the world. To give you an example, a forest on Barro Colorado Island has approximately five times more species of trees than a forest in southern Michigan. The avifauna of Panama perhaps is most reflective of the great species diversity that Panama has.

Taking into consideration a country that is only 75,000 square kilometers in size, we have 883 species of birds that have been identified, as compared to 800 for the United States and Canada. It is calculated that Panama possesses 4 percent of the species of reptiles in the world, as compared to only 5 percent for the United

States. So we're dealing with an area that is characterized by a great deal of biological diversity.

And that biological diversity shouldn't be examined just at the national level, where in Panama there exists 12 life zones using the Holdridge system. If we were to look at the Volcano Baru National Park, an area of only 20,000 hectares, 6 life zones of the Holdridge system have been identified there.

One of the great problems that we have in Panama, as well as in other tropical regions, is the existence of poor soils. In 1968 studies were conducted of land capability in Panama and it was found that approximately 23.6 percent of the soils of the country could be utilized for agriculture. Of this amount—of the total amount available in the country, we are only talking about roughly 2.6 percent that can be utilized, with moderate limitations. Obviously this, coupled with the population growth rate of about 2.8 percent over the last four decades, has contributed heavily to deforestation, especially when we consider that in Panama there is a tremendous need to carry out further research to design, to elaborate an agricultural technology that is suitable for the exploitation of these lands.

If we were to examine deforestation in Panama, we find it is extremely alarming. It is estimated that in 1850, 83 percent of the surface of Panama was in forest. By 1947, approximately 69 percent of the country remained in forest. But this rapidly declined to 52 percent in 1974. A recent report by the National Commission on the Environment placed the actual extension of the country's forests at 2.8 million hectares, or 37 percent of the total surface of the Isthmus. This represents the destruction of nearly 2.5 million hectares in 37 years. Between 50,000 and 70,000 hectares of forest are felled annually. This figure can climb considerably higher during extended dry seasons, as was the case in 1982–83, when approximately 100,000 hectares were destroyed.

Mr. SCHEUER. 100,000 hectares?

Mr. ILLUECA. Pardon me?

Mr. SCHEUER. 100,000 hectares?

Mr. ILLUECA. Yes, or 220,000 acres.

Of particular concern to Panama is the deforestation that has taken place in the country's most vital watershed, which is the watershed of the Panama Canal. The operation of the canal depends on the existence of forests which provide a stable water regime. Approximately 60 percent of the 320,000 hectares of this vital watershed have been deforested.

As I mentioned before, population growth has had a tremendous impact on the deforestation in the country, and this population growth isn't due just to natural birth rates but also to a very heavy immigration that the country has experienced, immigration from surrounding countries, immigration from the Orient, from Europe, from the United States. Panama, being the entrepot of much of the commerce of South America, attracts immigrants from many of the countries that are involved in that trade.

At the same time, given the fact that historically Panama has been politically one of the more stable countries in Latin America, we have at different periods experienced heavy immigration into the country, as is now the case with immigration from Central America into Panama. So all of this has contributed to this very

high population growth rate of about 2.8 percent. And we're talking that the population of the country at this rate will be doubling approximately every 30 years.

Mr. SCHEUER. I think at some point in time somebody ought to say that Panama does have one of the best family planning programs in Latin America.

Mr. ILLUECA. It does, it does, and that's the reason I wanted to qualify that much of the—that part of the population growth rate is due to immigration.

Mr. SCHEUER. Yes.

Mr. ILLUECA. Given the dimensions and complexity of the problem of tropical forest development, Panama is confronted with an extremely difficult and seemingly overwhelming task. The subjects of environmental management and natural resource development are relatively new fields in the country, and the government bodies that are charged with these responsibilities have only been created within the past 12 years. The Direction of Natural Renewable Resources was created in 1973, the Institute of Agropastoral Investigations 2 years later in 1975, and the National Commission on the Environment in 1983.

Insufficient scientific and technological data poses as the greatest obstacle to designing an effective development and management plan for the humid neotropics. This is perhaps best summarized by the following recommendation of the Institute of Ecology:

> Given the long history of human disturbance of the ecosystems of the American tropics and the increasing degree to which these same environments are being stressed by man, a most pressing research need is development of land-use planning and environmental management methodologies that are not only ecologically sound but economically and socially viable as well. The innovation of such methodologies depends upon the collection of adequate data and on evaluation of the main environmental controls and determinants of agriculture, forestry, and other major human activities.

The planning of environmental development and management strategies in Panama is clearly limited by the lack of an appropriate data base. Land-use planning and the development of ecologically sound agropastoral technologies cannot be promoted without further research and experimentation.

I mentioned earlier the land capability studies that were conducted in Panama in 1968. This is the best that we have for natural resource planners and agropastoral planners. But it falls far short of what is required. To give an example, when these land capability studies were prepared for the Atlantic coast of Panama, they were prepared on the basis of one soil sample for 400 square kilometers.

Clearly, there is urgency to establish with greater accuracy the actual spatial limits of the different classes of lands according to specific limitations, appropriate uses, agricultural capacity and efficient management practices. Until this is accomplished, it is likely that incompatible land uses will continue to be developed, resulting in the loss of land productivity and increasing pressures on the country's remaining forests.

Rodrigo Tarte, who is now the director of the Tropical Agricultural Center for Research and Education in Costa Rica, and was past director of the Institute of Agropastoral Investigations in

Panama, contends that Panama's agropastoral frontiers need not be extended, and that spontaneous encroachment into forested areas must be avoided. Although there is great need for further research, appropriate agricultural technology can now be introduced to increase production on existing farmlands.

I would like to qualify this again by saying that there is a tremendous need for research, to design appropriate agricultural technology, but actually there does exist agricultural technology that could be transferred and adopted by producers, and there's a tremendous need to continue to develop new agricultural technology. However, one of the most pressing problems that we have in Panama is that not only is it costly to conduct the research and experimentation to develop new agricultural technology, but the actual transferrence of agricultural technology, which is a very, very key issue, is extremely difficult and extremely costly.

Of the 100,000 producers that we have in the country right now, the Institute of Agropastoral Research has the capacity of reaching less than 10,000. Consequently, what's——

Mr. SCHEUER. Reaching them in what way, Mr. Illueca?

Mr. ILLUECA. Reaching them directly through educational programs, by providing them with direct technical assistance, by distributing new varieties of plants and seeds, by advising them on how to control pests and disease. So there is a very direct contact with the producers. But as I mentioned before, it's because of financial limitations that less than 10,000 producers can be reached.

Mr. SCHEUER. Let me--let me understand this. We heard from Mr. Lutzenberger that in Brazil the problem seems to be a really wrong-headed public policy making on the part of the Brazilian Government, extremely ill-conceived agricultural development programs, which result in the destruction of the rain forests of the Amazon for the purpose of exporting soybeans to the European cattle growers. It doesn't seem to be in the national interest of Brazil, with fewer people being supported on those lands, and a reduction of 90 percent in the cattle productivity per acre or per hectare. So it seems to me that there the problem is to turn around the Government of Brazil with perhaps a little gentle prodding from the World Bank, if we can turn them around, too.

Is the problem in Panama one of inept or wrong-headed public policy making on the part of the Republic of Panama, or is it lack of resources to do the good things that they want to do but simply don't have the resources to do? What is the basic fundamental problem in Panama as compared to the problem in Brazil as we have just heard it?

Mr. ILLUECA. I think maybe they can be divided into three basic problems. One, as I mentioned before, is that the importance of an ecologically sound management of natural resources is a relatively recent concept in Panama. This means that the infrastructure required for the development of sound land management practices still remains somewhat inexperienced. And this leads, of course, to the second reason, which would be the lack of human and physical resources for the carrying out of the activities.

I think a third problem, and it's a very important problem, is that there does exist a degree of inefficiency in the administration of the environment in Panama, which I think is partly due to the

fact that this is a field that has only been evolving over the last 10 to—approximately the last 10 or 11 years. As a consequence, there is lacking a lot of coordination of the different institutions that have a role in environmental management.

In a survey—in a very detailed survey that the National Commission on the Environment conducted in the early part of this year, we identified 19 different institutions in the country that had some sort of a role in the management of the environment. One of the things that we discovered, which really wasn't very difficult to predict, is that there was a lack of coordination, not necessarily a lack of good will, but a lack of coordination, so that in some areas you had incredible vacuums that existed.

For instance, very little attention has been given to the environmental management of the country's marine resources, which in Panama are even more impressive than its terrestrial resources. We have marine ecosystems that are found no where else in the world. To give you an example, the Gulf of Chiriqui has the most developed coral ecosystems in all of tropical Latin America. This is, to an extent, reflected in our exports. Our second leading export are fish products.

On the other hand, you'll have tremendous duplication of effort in other areas, specifically dealing with the management of terrestrial natural resources, where there can exist as many as six or seven different institutions that are duplicating their efforts in that area. I think that a certain degree of duplication is required, but at the same time, when it reaches a level that resources are not being applied adequately, this can be serious, given the fact that we are suffering from a paucity of resources.

Mr. SCHEUER. Are you getting any help in terms of these planning and infrastructure needs from our AID Program——

Mr. ILLUECA. Yes, we are.

Mr. SCHEUER [continuing]. The agricultural aid sector?

Mr. ILLUECA. Yes, we are. AID has a very important project that is being developed jointly with the Direction of Natural Renewable Resources in the Ministry of Agriculture in Panama. But the project itself reflects some of these institutional problems that I've been discussing. Much of the project, which is approximately a $6 million assistance program, focuses on the development of institutional—of institutional capabilities, and a certain percentage deals with reforestation.

Mr. SCHEUER. Well, you're telling us that that's what you really need, improvement of infrastructure.

Mr. ILLUECA. We need improvement of infrastructure, I would say specifically in the areas of research and investigation. At the same time, however, I feel that one of the problems is, given the fact that the environmental focus is being given importance, it lacks definition. I would say that today the Government of Panama—actually, not today, but over the last 10 years—has given a great deal of importance to environmental affairs. But that importance tends to be more a verbal and philosophical expression rather than a monetary one. It's not to say that the country wouldn't like to make that financial commitment. It's that these are very difficult times, these are very difficult economic times for the Latin American countries. Nonetheless, in the face of budget

cuts, the few environmental institutions that are in the public sector have been given I think a fair amount of support over the past few years. But it still is insufficient.

And again, given the fact that, as I mentioned before, our environmental situation is so complex and so delicate, we're in an extremely difficult situation in terms of carrying out the necessary research. The University of California alone has a budget equal to the Republic of Panama, nine campuses.

Mr. SCHEUER. All right, Mr. Illueca. Would you like to sum up in just a moment?

Mr. ILLUECA. Yes. There is one point I would like to express before summing up, what I think are certain activities that could be promoted by multilateral development banks. Getting back to the problem of deforestation and population growth, one of the alarming phenomena, an alarming phenomena that has occurred in the country over the past 10 or 15 years is the desertification or the creation of deserts in one particular region of Panama, which is the Peninsula de Azuero. The Sarigua Desert today is estimated to have an extension of approximately 100 square kilometers—and I'm talking about an area that looks very much like a desert in Arizona or in California. That desert is extending at a rate of 100 meters per year——

Mr. SCHEUER. Agricultural land reverting to desert?

Mr. ILLUECA. Yes, and specifically—not so much agricultural land, but lands that have been overgrazed.

Mr. SCHEUER. Yes.

Mr. ILLUECA. One of the main problems that we have in Panama is overgrazing.

Mr. SCHEUER. Too many animals and too many people trying to live on too fragile an ecosystem.

Mr. ILLUECA. Yes.

Mr. SCHEUER. Of course, that's a problem we have all over the world. I just flew from New Delhi to Katmandu, the capital of Nepal, and to fly over those mountains, it's a very short flight. You feel like crying, to see what they've done in terms of deforesting the mountains and the resultant flash floods and the desertification in that area. What we have done to the environment all over the world in terms of desertification and deforestation is absolutely pitiable.

[The prepared statement of Mr. Illueca follows:]

STATEMENT OF
JORGE E. Illueca, Ph.D.

On behalf of

The National Commission on the Environment,
Ministry of the Presidency,
Republic of Panama

AGRICULTURAL DEVELOPMENT PROBLEMS AND DEFORESTATION IN PANAMA

Introduction

The Isthmus of Panamá lies within the humid Neotropics, one of the most diverse and complex ecological regions on earth. Tropical forests are among the oldest of the earth's ecosystems, and have evolved a greater variation of flora, fauna and soils than any other terrestial biome. It is estimated that humid tropical ecosystems support as much as 90 percent of the earth's species of flora and fauna (Fosberg, 1973).

In the case of Panamá, its biotic diversity was greatly augmented by its geographic position. Towards the end of the Pliocene epoch, approximately three to five million years ago, Panamá emerged from the sea as a land bridge connecting the two American continents. Thus, the Isthmus became a field laboratory which brought in contact the flora and fauna of the North America and South American neotropical zones.

A special feature of Panamá is the extraordinarily high diversity of species found within a relatively small territory of 75,616 square kilometers. This is partly due to the flow and mix of species between the two continental masses, but is also the product of the wide variation of topographical and climatic conditions existent throughout the Isthmus. The variation of abiotic conditions resulted in the evolution of numerous ecosystems, each with its own integrated structure of organized communities, nutrient requirements and energy cycles.

A one hectare plot of forest on Barro Colorado island in Lake Gatun in the watershed of the Panamá Canal contains between 50 and 65 species of trees over 20 cms in diameter, as compared to 10 to 12 species in a hectare of a southern Michigan oak-hickory forest (Leigh, 1982; Foster, et al 1982). Moreover, this relatively small island of 1,600 hectares contains about 1,300 species of vascular flora.

Panamá's tropical forests are rich in epiphytes and vines. Approximately 650 species of orchids alone have been recorded in the country, with the actual number probably being double that figure (Dressler, 1972). Of the 180 new species identified since 1949, 8.7 percent are undescribed for other regions.

The great variability of species in the Panamanian tropics is well illustrated by its avifauna. Eight hundred and eighty-three species of birds have been identified on the Isthmus, as compared to only 800 species for all of North America above Mexico (Ridgely, 1976; Wetmore, 1972). Forty species of birds have been identified exclusively in the highlands of Chiriquí Province (La Bastille, 1973).

Given its small size, the Isthmus has a surprisingly large and complex mammalian fauna that has few equals on earth (Handley, 1972). Two hundred and twenty-seven species were identified by 1971, including eight species of primates.

Although the entomology of Panamá is far from complete, insects are the largest group of species in the country. Soil litter fauna on Barro Colarado Island alone account for over 400 species, four times the number found in a comparable study in Illinois; a square meter of floor litter on the island in one investigation contained 19,474 insects (Churchill, 1940).

The herpetology of the Isthmus also illustrates the remarkable species diversity of this small geographic area. Charles W. Meyer (1972) of New York's American Museum of Natural History has estimated that 4 percent of the planet's living species of amphibians and reptiles exist here, in contrast to only 5 percent in the vastly larger territory of the United States.

SOILS

Panamá like most neotropical regions, does not possess large extensions of fertile soils. It is a mistake to assume that the enormous diversity of floral and faunal species in the tropics is predicated on the existence of rich soils. The abundant rainfall of the tropics tends to leach the soils of their nutrients. Consequently, the greater part of tropical soils are low in bases and highly acidic, making difficult the retention of essential elements such as calcium and phosphorous and nitrogen fixation (Janick, et al, 1976). Lands which have suffered little disturbance may enjoy a thin rich top soil, usually twelve inches or less in thickness, composed largely of humus and organic matter. Once the natural vegetation cover is removed, it is quickly exhausted, resulting in the exposure of an acidic lower soil with a pH value of approximately 5. Most agricultural plants require a soil pH value between 6 and 7 (Kellogg, 1950). The lush vegetation of the humid tropics is due primarily to the ability of plants to rapidly absorb and recycle the nutrients released by decaying organic matter before they can be leached away by the rains (Jordan, 1977; Farnworth, et al, 1974). It is estimated that approximately 70 percent of the total mineral nutrient supply of a humid tropical forest is contained in its living biomass (Fosberg, 1973). This rapid process of recycling nutrients is characteristic of the specialized biological adaptation of tropical plants. In this manner they have been able to compensate for poor soils and the leaching effects of high precipitation. The efficiency of this system, has contributed to the enormous floral and faunal speciation of the humid tropics.

Consequently, tropical soils as a whole do not lend themselves to intensive agriculture. The natural fertility of the rich but thin top soil is conserved only as long as the protective, replenishing forest cover is maintained. Once this cover is eliminated, the soils are exposed to increased temperatures, accelerated leaching of nutrients and structural changes. Moreover, the reduction or elimination of plants and animals usually results in the removal of essential species which play roles in recycling mineral nutrients, regenerating other species or preserving the equilibrium of these delicate ecosystems.

According to land capability studies realized by the Panamanian government with the assistance of the Agency for International Development,

23.9 percent of Panamá's lands are arable (see Table 2). Approximately half of these arable lands are at best of marginal utility for intensive agriculture and require great care and management in order to remain productive. Only 2.6 percent of the country's soils can be exploited under moderate limitations (see Table 3).

This land capability assessment is based on an analysis of soil types, topography, susceptibility to erosion, drainage, soil structure and climatic conditions, and utilizes the classification system for agricultural capacity employed by the U.S. Soil Conservation Service. The purpose of this system of classification is to group soils according to appropriate uses, specific limitations, efficient management practices and suitable crops. Lands are divided into eight categories according to ag-

TABLE 1

CLASSES OF SOILS ACCORDING TO LAND CAPABILITY

Class of Soil	
I:	Arable with few limitations restricting exploitation.
II:	Arable with some limitations in the selection of plants; requires moderate conservation.
III:	Arable with severe limitations in the selection of plants; requires special conservation management.
IV:	Arable with very severe limitations in the selection of plants; requires very careful management.
V:	Nonarable, little risk of erosion, but with other limitations; apropriate for forests and pastures.
VI:	Nonarable with severe limitations, appropriate for forests, reserves and pastures.
VII:	Nonarable with very severe limitations; appropriate for forests, reserves and pastures.
VIII:	Nonarable with limitations that impede use for any commercial purpose.

Source: República de Panamá, Presidencia de la República, Dirección General de Planificación y Administración, Evaluación preliminar de los recursos agri-físicos de la República de Panamá (Panamá, September, 1971), 42.

TABLE 2

GROUPED FREQUENCY DISTRIBUTION OF SOILS IN THE REPUBLIC OF PANAMA ACCORDING TO LAND CAPABILITY BY PROVINCE (HECTARES)

Province		Arable Soils (Classes II-IV)	Nonarable Soils (Classes V-VIII)
Bocas del Toro	Frequency	157,070	709,060
	Row percent	18.13	81.86
	Column percent	9.08	12.85
Coclé	Frequency	119,600	383,255
	Row percent	23.78	76.21
	Column percent	6.91	6.95
Colón and Comarca de San Blas	Frequency	101,940	537,455
	Row percent	15.94	84.06
	Column percent	5.89	9.74
Chiriquí	Frequency	226,725	638,670
	Row percent	26.20	73.80
	Column percent	13.10	11.58
Darién	Frequency	469,790	1,156,590
	Row percent	28.89	71.11
	Column percent	27.15	20.97
Herrera	Frequency	75,025	160,180
	Row percent	31.90	68.10
	Column percent	4.33	2.90
Los Santos	Frequency	99,025	285,955
	Row percent	25.72	74.28
	Column percent	5.72	5.18
Panamá	Frequency	295,010	777,935
	Row percent	27.49	72.50
	Column percent	17.05	14.10
Veraguas	Frequency	186,335	866,945
	Row percent	17.69	82.31
	Column percent	10.77	15.72
TOTAL	Frequency	1,730,520	5,516,045
	Row percent	23.88	76.12

Source: See Table 1

TABLE 3

FREQUENCY DISTRIBUTION OF SOILS IN THE REPUBLIC OF PANAMA
ACCORDING TO LAND CAPABILITY BY PROVINCE

PROVINCE		Class of Soil (Hectares)							TOTAL
		II	III	IV	V	VI	VII	VIII	
Bocas del Toro	Frequency	15,360	95,065	46,645	0	101,555	390,455	217,050	866,130
	Row percent	1.77	10.98	5.38	0.00	11.72	45.08	25.06	100.00
	Column percent	8.05	13.93	5.44	0.00	9.82	10.78	26.29	11.95
Coclé	Frequency	26,600	45,340	47,660	2,640	74,815	153,130	152,670	502,855
	Row percent	5,29	9.02	9.48	0.52	14.88	30.45	30.36	100.00
	Column percent	13.98	6.64	5.56	7.73	7.24	4.23	18.49	6.94
Colón and Comarca de San Blas	Frequency	13,530	23,075	65,335	440	93,365	417,800	25,850	639,395
	Row percent	2.17	3.61	10.22	0.07	14.60	65.34	4.04	100.00
	Column percent	7.09	3.38	7.62	1.29	9.03	11.53	3.13	8.82
Chiriquí	Frequency	65,535	82,920	78,270	28,995	133,540	384,995	91,180	865,395
	Row percent	7.57	9.58	9.04	3.35	15.43	44.49	10.54	100.00
	Column percent	34.36	12.16	9.13	84.95	12.92	10.63	11.04	11.94
Darién	Frequency	5,895	223,885	240,010	0	235,335	821,400	99,855	1,626,380
	Row percent	0.36	13.77	14.76	0.00	14.47	50.50	6.14	100.00
	Column percent	3.09	32.80	28.00	0.00	22.77	22.67	12.09	22.44

TABLE 3 .-Continued

PROVINCE		Class of Soil (Hectares)							TOTAL
		II	III	IV	V	VI	VII	VIII	
Herrera	Frequency	8,905	28,675	37,445	0	41,945	114,560	3,675	235,205
	Row percent	3.79	12.19	15.92	0.00	17.83	48.71	1.56	100.00
	Column percent	4.67	4.20	4.37	0.00	4.06	3.16	0.44	3.25
Los Santos	Frequency	23,380	20,270	55,375	0	53,520	229,695	2,740	384,980
	Row percent	6.05	5.26	14.38	0.00	13.90	59.66	0.71	100.00
	Column percent	12.26	2.97	1.79	0.00	5.18	6.34	3.32	5.31
Panamá	Frequency	9,410	102,490	183,110	1,800	189,345	546,580	40,210	1.072,945
	Row percent	0.88	9.55	17.07	0.17	17.65	50.94	3.75	100.00
	Column percent	4.93	15.01	21.36	5.27	18.32	15.09	4.87	14.81
Veraguas	Frequency	22,095	60,845	103,395	295	110,310	563,905	192,435	1,053,280
	Row percent	2.10	5.78	9.82	0.03	10.47	53.54	18.27	100.00
	Column percent	11.59	8.91	12.06	0.86	10.67	15.56	23.31	14.53
	Frequency	190,710	682,565	857,245	34,130	1,033,730	3,722,520	825,655	7,246,565
	Row percent	2.63	9.42	11.83	0.47	14.26	51.37	11.39	100.00
	Column percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Computed from República de Panamá, Presidencia de la República, Dirección General de Planificación y Administración, Evaluación preliminar de los recursos agro-físicos de la República de Panamá (September 1971), 37, 42, 49, 59, 64, 79, 81, 90 and 98.

ricultural capacity. Limitations for agriculture, as well as land practice needs, increase progressively from class I through VIII. No class I soils, arable lands with few limitations, are found in any region of Panamá. Although these studies are an important advancement towards understanding the quality and distribution of soils in Panamá, there is, nonetheless, a great need for more precise investigations based on a wider sampling of soils and a more complete record of climatic conditions.

DEFORESTATION

Limitations in the understanding of environmental conditions have severely restricted the development of intensive agriculture in the humid tropics. As a result of greater environmental complexity and poorer soils, agricultural technology suited for intensive cultivation has been slow to develop in humid tropical regions. In fact, according to the report of the third workshop of the Institute of Ecology, there has yet to be formulated an adequate conceptual base for designing sound and rational development plans for the Neotropics that would allow for optimum economic development while safeguarding environmental stability (Farnworth, et al, 1974).

Deficiencies in agricultural technology, particularly among economically disadvantaged slash-and-burn farmers, too often result in the deterioration and, subsequently, the abandonment of farmlands. This in turn creates new pressures on tropical forests as trees are felled to make room for new farmlands which are commonly abandoned three to five years later by these farmers. Moreover, the new lands which are colonized today are generally more marginal and less fertile since historically the more productive soils were first to come under exploitation.

In Panamá, as well as in much of Central America, forest regeneration on abandoned farmlands is deflected by the rapid conversion of these lands into pastures for cattle raising. This process is greatly accelerated by the tendency of banks in the country to favor cattle over agricultural producers in their lending practices (Comisión Nacional del Medio Ambiente, 1983).

Animal grazing contributes heavily to the further erosion of these degraded lands to the degree that many are incapable of supporting the growth of natural forests or cultivations in the foreseeable future without the injection of sizeable investments. Pastures today account for 1.2 million hectares of degraded and eroded lands (Chakroff, 1980). A major concern in Panamá is the increasing desertification of overgrazed lands in the Peninsula of Azuero, where the Sarigua Desert advances at an estimated rate of 100 meters annually and presently covers an area of approximately 100 square kilometers.

Other reasons for deforestation are commercial logging operations and fuelwood gathering.

Deforestation in the humid tropics has reached critical proportions. It is estimated that 260,000 square kilometers of tropical forest (an

area nearly three-and-a-half times the size of Panamá) are destroyed yearly throughout the world. At present the annual rate of deforestation of the remaining forests in neighboring Costa Rica is around 4 percent, and is 0.4 percent in Brazil, the largest reservoir of tropical forests in the world today. At these rates humid tropical forests will be tottering on the precipice of extinction by the next century. In the coming years this will signify the disappearance of around one million species, many with potential benefits to humanity (Rubinoff, 1984).

Like other tropical countries, the rate of deforestation in Panamá is alarming. It is estimated that 83 percent of the surface of the Isthmus was in forest in 1850 (Illueca, 1977). By 1947 approximately 69 percent of the country remained in forest, but this rapidly declined to 52 percent in 1974 (Chakroff, 1980). A recent report by the National Commission on the Environment placed the actual extension of the country's forests at 2.8 million hectares, or 37 percent of the total surface of the Isthmus. This represents the destruction of nearly 2.5 million hectares in thirty-seven years. Between 50,000 and 70,000 hectares of forest are felled annually. This figure can climb much higher during extended dry seasons, as was the case in 1982-83 when an estimated 100,000 hectares were destroyed (Comisión Nacional del Medio Ambiente, 1983).

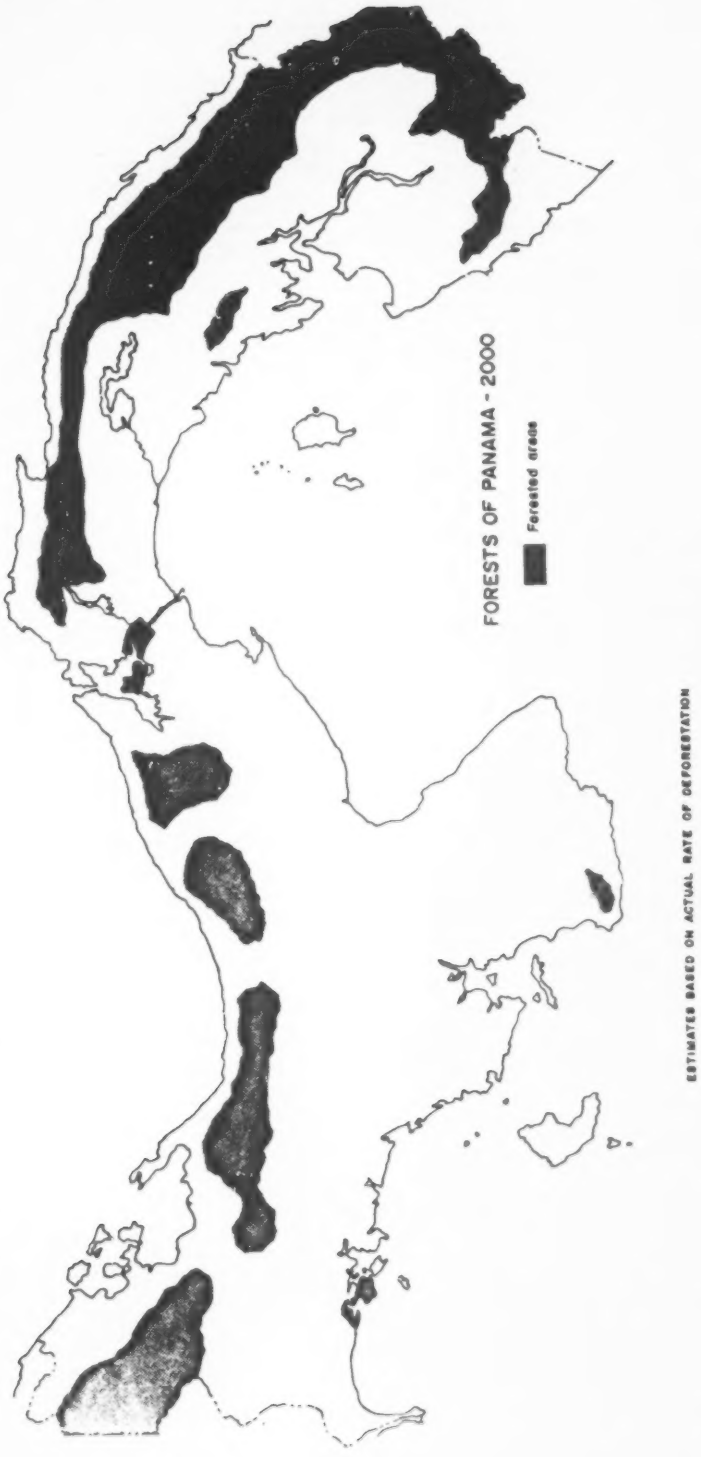
TABLE 4

SURFACE AREA OF FORESTS
IN PANAMA, 1850 - 1984

Year	Surface (Km^2)	Percentage
1850	62,761	83.0
1947	52,450	69.4
1974	39,000	51.6
1984	28,000	37.0

Sources: Jorge E. Illueca Bonett, "Tendencias Poblacionales y su Impacto Sobre el Medio Panameño 1800-1920," Revista Nacional de Cultura (Panamá), Nos.7-8 (April-Sept., 1977); Marilyn S. Chakroff, ed., Panamá: Perfil Ambiental del País, 1978; and Presidencia de la República, Comisión Nacional del Medio Ambiente, "Compendio de Documentos Analíticos: Elementos Básicos para la Planificación Ambiental en la República de Panamá," 1983.

FORESTS OF PANAMA - 1983
Forested areas


FORESTS OF PANAMA - 2000
Forested areas
ESTIMATES BASED ON ACTUAL RATE OF DEFORESTATION

Of particular concern to Panamá is the deforestation that has taken place in the watershed of the Panamá Canal. The operation of the Canal depends on the existence of forests which provide a stable water regime. Approximately 60 percent of the 326,000 hectares of this vital watershed are deforested.

The explosive demographic growth that the country has experienced since the mid-nineteenth century has contributed in part to this excessive deforestation. The population of the Isthmus has increased from 128,897 in 1851, to 622,576 in 1940, to 1,824,796 in 1980 (Illueca, 1983). This translates into an annual growth rate of 2.7 percent over the past half century.

Population growth has been especially marked in the Peninsula de Azuero, the most densely inhabited region of the country. Deteriorating environmental conditions, poor agropastoral technology, the spread of cattle grazing and the limited availability of lands for farming are some of the factors which force lower level producers out of this region and into forested areas of eastern Panamá, the Caribbean and the higher reaches of the Continental Divide. As indicated earlier, this spontaneous colonization of forested lands is soon afterwards followed by the introduction of cattle and the encroachment of pastures.

LIMITING FACTORS IN MANAGING THE ENVIRONMENT

Given the dimensions and complexity of the problem of tropical forest development, Panamá is confronted with an extremely difficult and seemingly overwhelming task. The subjects of environmental management and natural resource planning are relatively new fields in the country, and the government bodies charged with responsibilities in these areas have only recently been created. Consequently, their experience is limited and they are still in the process of acquiring and developing the human and physical resources needed to carry out their functions. The Direction of Renewable Natural Resources (RENARE) of the Ministry of Agropastoral Development was formed in 1973. The Institute of Agropastoral Research of Panamá (IDIAP) came into existence in 1975, while the National Commission on the Environment (CONAMA) was established by presidential decree in 1983.

Because of the recent emergence of these fields, an adequate legal framework has yet to be developed which would provide a fundamental basis for the management and protection of the environment. Legal definitions for such essential concepts as "contamination" and "environmental impact assessment" have yet to be formulated. Over 780 laws, decrees and resolutions exist which have a bearing on the management and protection of the environment, but are often unclear, obsolete and contradictory. The elaboration and passage of a national organic law on the environment, which is a priority project of the National Commission on the Environment, is required to resolve these contradictions and bring legal order to the administration and management of the environment.

Insufficient scientific and technological data poses as the greatest obstacle to designing an effective development and management plan for the

humid Neotropics. This is perhaps best summarized by the following recommendation of the third workshop of the Institute of Ecology:

> Given the long history of human disturbance of the ecosystems of the American tropics and the increasing degree to which these same environments are being stressed by man, a most pressing research need is development of land-use planning and environmental management methodologies that are not only ecologically sound but economically and socially viable as well. The innovation of such methodologies depends upon the collection of adequate data on and evaluation of the main environmental controls and determinants of agriculture, forestry, and other major human activities. Vitally important is the recognition that the existing data base for environmental parameters such as microclimatology, pedology, hydrology, biota, geomorphology and geologic structure is insufficient for the development of ecologically sound land-management practices that are applicable to the American tropics (Farnworth, et al, 1974).

RESEARCH AND THE TRANSFERENCE OF TECHNOLOGY

The planning of environmental development and management strategies in Panamá is clearly limited by the lack of an appropriate data base. Land-use planning and the development of ecologically sound agropastoral technologies cannot be promoted without further research and experimentation.

For example, the afore-mentioned land capability studies completed by the Panamanian government with the cooperation of USAID in 1968 lack sufficient definition to permit efficient land-use planning. An average of one soil sample per 400 square kilometers was collected along The Caribbean coast of the eastern half of the Isthmus.

Clearly there is urgency to establish with greater accuracy the actual spatial limits of the different classes of lands according to specific limitations, appropriate uses, agricultural capacity and efficient management practices. Until this is accomplished it is likely that incompatible land uses will continue to be developed, resulting in the loss of land productivity and increasing pressures on the country's remaining forests.

The importance of conserving tropical forests has been amply reviewed in the literature (Elfring, 1984). Major functions include the maintenance of the productivity of marginal lands for agriculture, preservation of soil quality, prevention of erosion and siltation, regulation of water regimes and production of selected forest goods. In Panamá they play crucial roles in providing stable water regimes for the operation of the Panamá Canal and the country's five hidroelectric plants. The further development of this nation's rich hydroelectric resources in western Panamá depends on their preservation.

Nonetheless, an integrated approach is needed for the exploitation and management of these forests even if they are not destined for agricultural use. Various emerging technologies for sustaining forest productivity, including agroforestry, charcoal production, exploitation of native species for food and medicines, and production of building materials, must be tested and modified.

Reforestation and arboreal plantation technology also require considerable research. Various tropical forestry utilization and regeneration practices have been proposed, but have yet to be fully evaluated and tested. Natural succession of the country's cleared lands is not automatic, taking up to 400 years to re-establish mature forests. Reforestation through plantation practices is complex and must be well thought out and planned to avoid a myriad of environmental problems.

Rodrigo Tarté, director of the Tropical Agricultural Center for Research and Education (CATIE) in Costa Rica and past director of IDIAP, contends that Panama's agropastoral frontiers need not be extended, and that spontaneous encroachment into forested areas must be avoided. Although there is great need for further research, appropriate agricultural technology can be introduced to increase production on existing farmlands.

This is a critical issue in the economic future of the country. Given the high demographic growth, each year the food requirements of the population rises, creating additional pressures on forests and contributing to the general problem of soil degradation throughout the Isthmus. The design and transference of an ecologically sound agricultural technology is crucial for achieving a sustainable economic development.

Yet the costs involved in the research and transference of technology too often are prohibitive. FAO calculates that the developing and underdeveloped countries of the world will need to invest $1.69 trillion in agriculture between 1980 and 2000 to meet the nutritional needs of their peoples by the latter date.

Important research advancements have been made in Panamá which are a solid beginning in the elaboration of a program of ecologically sound agricultural practices (Tarté, 1984). Moreover, new technology has been successfully introduced and is reflected in higher crop yields. These advancements include the development of varieties of plants such as tomatoes, corn, potatoes, peppers and flame with greater resistance to diseases. New varieties of soybeans have not only been introduced, but have been successfully cultivated through innovative technological practices. Integrated systems of biological control of agricultural pests are in the process of being developed, and have been successfully applied in the cultivation of potatoes and sorghum. Research into the more efficient use of fertilizers is being conducted and has yielded positive results for farmers in Panamá's central and western provinces.

Aside from the high costs involved in the research and development of agricultural technology, the actual transfer and adoption of new practices require substantial investments. According to Tarté, the former director

of IDIAP, limited institutional capacity is the major obstacle to introducing appropriate and innovative technology to farmers and ranchers. IDIAP provides less than 10,000 of the country's 100,000 agropastoral producers with technical assistance and support.

Approximately 45 percent of Panamá's agropastoral lands are in disuse today (Tarté, 1984). A more rational and intensive exploitation of these lands is needed to satisfy the nutritional requirements of a growing population, while at the same time safeguarding the country's precious and fragile forest resources.

Reforestation is also an expensive activity that in this country has been carried out almost exclusively by RENARE. Because of the costs involved, the extent of reforestation has been limited, and in 1979 only 4,500 hectares had been replanted principally with Pinus caribaea. Current projects are being implemented with the support of AID. Nonetheless, the investments required for reforesting the country's severely eroded lands, which today are in excess of 1.8 million hectares, is prohibitive. At current rates of $600.00 per hectare, the reforestation of these unproductive lands would reach $1.080 billion (Comisión Nacional del Medio Ambiente, 1983).

THE ROLE OF BANKS IN THE DEVELOPMENT OF THE PANAMANIAN TROPICS

In a major report on cattle activities and deforestation presented to the Presidential Cabinet in January of 1984, CONAMA addressed the need to reorientate bank credit as a tool for improving the utilization of the country's natural resources (Comisión Nacional del Medio Ambiente, 1983). The report recommended the discouragement of loans favoring the encroachment of ranching into forested areas. At the same time, it favored the granting of loans as incentive for agroforestry and forest development.

From 1968 to 1975, with the aid of international and local lending institutions, the government of Panamá tripled the amount of credit available for agropastoral development. Unfortunately, this credit contributed little to the development of production based on approriate land use management (Chakroff, 1980). Moreover, of the total sum of $160 million in agricultural credit for 1977, 40 percent was invested in animal husbandry, contributing in large part to the excessive deforestation which the Isthmus has experienced over the past two decades. Loans were provided principally through the Agropastoral Development Bank (BDA), but also by the Interamerican Development Bank (BID), the World Bank and private commercial banks.

The Interamerican Development Bank has considered since 1979 the financing of a loan to be administered by RENARE for a massive reforestation project inthe provinces of Veraguas and Chiriquí. Commercial species of trees would be planted on 20,000 hectares over a period of five years. Although the Ministry of Planning and Political Economy has expressed interest in this project, both for its commercial and intensive employment potentials, it has yet to be formalized.

RECOMMENDATIONS

This report has focused on several important themes that must be evaluated in assessing the status of environmental management practices in the Republic of Panamá: (1) the complexity and fragile nature of the country's various ecosystems; (2) the paucity of scientific data for the formulation of ecologically sound natural resource management practices, including the preparation of detailed land use plans; (3) the alarming rate of deforestation, with its subsequent loss of species diversity; (4) the need to raise agricultural productivity in the face of an annual population growth rate of 2.7 percent; (5) the elevated investments required for the formulation and transfer of innovative agricultural as well as forestry technology; and (6) the prohibitive costs involved in reforesting severely eroded lands.

Research, the transfer of technology, the development of agriculture based on sound land management practices, agroforestry and reforestation are all projects that require considerable investments. However, their promotion and development must be viewed as essential and unavoidable steps in the modernization of the country's economy. Given the economic difficulties that Panamá is experiencing, the international banking community could be expected to assume a major role in this process of modernization. To achieve this the following recommendations should be considered.

1) Reforestation projects based on commercial species should be promoted, particularly in areas where the existence of forests is necessary for the operation of other economic activities. Priority areas for such projects in Panamá would be the watersheds of the Panamá Canal and the hydroelectric plants. Not only would these plantation forests provide the Canal and the hydroelectric plants with stable water regimes while reducing siltation, they would also create economic opportunities and income that would occupy many of the same slash-and-burn farmers that are the agents of deforestation. At the same time they would contribute to agricultural productivity and to a more positive balance of trade. The financing of such projects should take into consideration requirements for research and the testing of appropriate, innovative practices.

2) Exploitation of native forest species, based on careful research of ecological conditions, should also be promoted. Tropical forests provide a wide variety of foods, medicines and industrial materials that can be consumed locally or exported.

Ira Rubinoff, Director of the Smithsonian Tropical Research Institute (STRI), makes a strong argument for the establishment of biological reserves throughout the tropics financed by the developed nations, in order to protect a majority of tropical forest species. Part of the justification for the creation of these reserves is to preserve species with potential as sources of medicines, oils and foods. STRI is currently involved in innovative research of potential commercial forest species in Panamá.

3) Experimental projects in the forest management of commercial arboreal species such as cativo (Prioria copaifera), cuipo (Cavanilesa platanifolia) and orey (Camonosperma panamensis) sould be developed. Such projects should also study the forms in which these woods could be prepared for market

4) Agricultural projects which utilize innovative and appropriate technology for intensifying production should be encouraged. All such projects should be accompanied by research programs for monitoring and, if necessary, correcting the impact of these technological practices on the environment. Priority should be given to those projects that are labor intensive and/or provide opportunities for the adoption of new technology by lower level producers.

5) Multilateral lending institutions must develop environmental data banks as aids for assessing the ecological soundness of proposed projects. Special offices charged with this function could collaborate closely with the project developers in providing information and supporting necessary research.

6) In Panamá's case, a pilot research project on the development and conservation of the watershed of the Canal is of the utmost importance. This would require the preparation of an integrated model for the development of the watershed's natural resources based on appropriate land and water management practices. The model could be utilized for planning compatible multiple natural resource development projects for the Canal region as well as other watersheds.

7) A development assistance program in land use planning and zonification is urgently needed for countries like Panamá. Assessment and more detailed redefinition of existing land capability studies are required. This project should prepare maps with sufficient definition to be useful for natural resources development planners and managers. The preparation of this data base is essential for optimizing a sustainable economic development based on an appropriate and efficient exploitation of natural resources.

In conclusion, humid tropical countries are faced with a difficult dilemma. High rates of demographic growth require a more intensive exploitation of natural resources. Because of insufficient scientific information and, subsequently, limited technology, higher production goals are increasingly unattainable. The result is an exploitation of natural resources that becomes more extensive rather than intensive. Valuable tropical forests that are needed to sustain economic development continue to be destroyed until finally a point will be reached where total agropastoral productivity in tropical countries will begin to decline on a national scale. The consequences of such a scenario would be long term social, economic and political instability.

Multilateral development banks have the resources and technical capability to help avoid this situation. A greater commitment is required on their part to fortify sound development processes. This must include not only the promotion of needed natural resources development projects, but also of research oriented towards sound land use planning and environmental management methodologies.

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Mr. SCHEUER. We have enjoyed your testimony, although it hasn't been pleasant, but we have benefited from it very much, and we are grateful to you for coming here. We are very grateful to both Mr. Lutzenberger and you, Mr. Illueca. We may have some further questions for you by mail, and we will hold the record, the printed record, of this hearing open for such questions.

We thank this panel very much for some excellent and thoughtful and very provocative testimony. We are very grateful to you.

We will now get to the second panel, composed of Walter Parham, Director of the Food and Renewable Resources Program at the Office of Technology Assessment, and Tom Lovejoy, vice president for science of the World Wildlife Fund.

All right. We're very happy that you're here this morning. We look forward to your testimony. Your full prepared testimony will be printed in full in the record. We would ask you to sum up your testimony in about 5 or 6 minutes, each of you, and feel free to refer to anything you've heard from the prior witnesses.

First we'll take Mr. Parham. Please proceed.

STATEMENTS OF DR. WALTER PARHAM, PROGRAM MANAGER, FOOD AND RENEWABLE RESOURCES, OFFICE OF TECHNOLOGY ASSESSMENT; AND THOMAS E. LOVEJOY, VICE PRESIDENT FOR SCIENCE, WORLD WILDLIFE FUND—U.S.

Dr. PARHAM. Thank you, Mr. Chairman. It's a pleasure to appear before your subcommittee today to discuss sustainable agricultural development in humid tropical forest regions of Central and South America. My name is Walter Parham. I'm program manager of the Food and Renewable Resources Program at OTA.

This year we completed a study for the Congress on "Technologies to sustain Tropical Forest Resources." The summary has been put on the back table for those who are interested. Our study was primarily aimed at looking at the tropical forest resource itself, rather than focusing primarily on agriculture. However, in the process of looking at tropical forestry problems, we realized that agriculture played a major role in the loss of the forests. This is not only true of the wet, hot regions of Central and South America, but it's true worldwide within the tropical latitudes.

At this point we have conducted a few other studies in OTA, smaller studies, that deal with technologies that relate to tropical agricultural problems and solutions. However, we have not specifically addressed the technologies related to tropical agriculture, the problems and the opportunities. That's something, a potential study area, for the future.

The first two speakers and yourself, Mr. Chairman, covered pretty much the extent of the nature of the problem, the agricultural situation, how forests are used within the wet tropical areas. I might add that after seeing the film, the best figures we have to date are that, of the entire Amazon Basin, something like 6 percent of the soil resources there have no limitations as far as agriculture, versus 94 percent with severe problems.

I thought I would skip a little bit to two possible approaches. One is bringing nutrients into the forest—what we do in our own agricultural systems here in the United States and our forests—and

the other is trying to work within the system in the constraints that it has. There has been work in the United States at our various universities that have shown that fertilizing the soils in the Amazon Basin, for instance, do lead to certain success. However, the costs to the farmers in that part of the world, who we have already seen are very poor, is very, very high. The transportation and movement of such materials, and the quantities needed when we have a basin where only 6 percent of the soils have no limitations, seems to be an extremely difficult problem.

Not only do we have problems with just the logistics and the cost, we have problems associated—environmental problems that sometimes are overlooked. I have cited one in my testimony, where there is—it's interesting to note that within the Amazon Basin itself, in the central part, schistosomiasis, a common disease of many parts of the tropical world, does not exist. The best estimate of the reason for the lack of this disease within the Amazon is that the snail that carries the disease can't build its shell because the waters are so devoid of nutrients or calcium to build its shell.

If you go into a fertilizer practice of adding lime to your fields and fertilizers to your fields, you run the risk of providing the very nutrients for an organism that could cause you some problems. So there needs to be—not condemning the fertilizers—but I'm saying there needs to be some serious considerations to the chemical approaches to solutions of agriculture in those areas.

We have already heard that agroforestry, or the use of trees, combining trees with agricultural crops, is an effective way and perhaps may be one of the only ways of sustaining agriculture within the wet tropics. We have looked into this a little bit in our study and we feel that there is some fair potential here for developing systems that do include trees as well as crops. The techniques, some of them are called agroforestry, some of them without the trees are called polyculture—there's a whole variety of systems that are used. And because we only dealt with agroforestry in our system, I'll describe that a little bit. But properties of that system would be similar to some of the others.

Low input agricultural systems—and that's what agroforestry is—are systems in which man tries to design agriculture that fits into the environmental situation without trying to manipulate the environment to the food crops that are being planted. In other words, bring in crops that are adapted already to the particular environment. In the tropical regions some of these are very, very hostile soils and therefore it is a lot cheaper to bring in plant material that is adapted there, rather than trying to convert the environment to plants that are not so adapted.

Recently we have had—there has been some testimony in one of the other committees here in the House, the House Agriculture Committee, where land grant university representatives have been talking a different tone than we have heard before. They're beginning to say that even within the U.S. low-input agriculture systems probably are something that need more attention, rather than focusing primarily on production as a maximum goal. The same thing is true in the Peace Corps. We found that the Peace Corps is developing a program to focus on low-input agricultural systems. Recently, in one of our other studies at OTA, we had an individual

visit the International Institute for Tropical Agriculture in Africa, and the same thing is true there. They're moving away from the "green revolution" type agriculture to those systems that already exist but using science and technology to modify them somewhat for their benefit.

Similarly, last week we had a panel meeting and had some 20 experts on tropical agriculture at OTA on another study we're conducting, and without question, the entire group felt that the direction that we ought to be moving in is toward low-input agriculture and modifying the agriculture systems that are there in order to bring our science and technology to bear, but not completely change the entire picture.

Mr. SCHEUER. In other words, to work with the existing ecosystem——

Dr. PARHAM. Yes.

Mr. SCHEUER [continuing]. And the existing food chain and the existing rain forest or whatever, and somewhat improving agricultural techniques and seeds and processes and so forth.

Dr. PARHAM. That's correct.

Mr. SCHEUER. You've been going for 6 or 7 minutes. Perhaps you could sum up for us now.

Dr. PARHAM. All right.

Well, as far as the multilateral banks are concerned, they offer one opportunity to promote ecological research relevant to development and low-input agricultural technologies. Small research components could be added to multilateral development projects to investigate ecological requirements and impacts of their projects, and this information could be disseminated broadly to the institution, to other development organizations, and to the research community at large.

Through existing mechanisms, the United States has considerable influence over activities of multilateral banks and agencies, and U.N. agencies. The United States has two basic mechanisms for influencing the policies and programs of multilateral development banks: through the U.S. Treasury Department's Office of Multilateral Development Banks, and through the U.S. representatives to the banks. The Office of Multilateral Development Banks oversees administrative budgets and policy papers for multilateral development banks. The United States has representatives on the board of directors of the multilateral development banks. Voting rights are allocated in proportion to each nation's contribution to the bank. Therefore, the United States has an ability to have major impact on the kinds of activities that the multilateral development banks undertake.

They can influence the programs that are sought after by countries that are seeking loans. We would suggest that, in addition to the representatives to the banks encouraging low input agricultural systems in their portfolio, that the banks promote increasing emphasis during agricultural project design on the long-term sustainability of the agricultural production system; that they improve the monitoring and evaluation of agricultural projects to assure their long-term sustainability; that they increase the number of staff in their organizations having interdisciplinary agriculture/ecology

backgrounds; and that they expand and disseminate the publication of research findings from low-input agricultural projects.

Now, in order for this to take place, and in order for the United States to contribute in a strong way to it, we will have to rely on our educational institutions. But as an example of part of the problem that may occur, is the fact that today, as far as we know, there are only three textbooks in the United States used at a college level that have even linked the word "agriculture" and "ecology" together—one from the University of California at Berkeley, one from the University of California at Davis, and the other one is in press or just released.

That doesn't mean that other institutions aren't thinking agriculture and ecological things are important, but the mere fact that there are so few that explicitly state that suggests that we may have some problems right here at home.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Parham follows:]

TESTIMONY OF WALTER PARHAM
PROGRAM MANAGER, FOOD AND RENEWABLE RESOURCES
OFFICE OF TECHNOLOGY ASSESSMENT
BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURAL RESEARCH AND ENVIRONMENT

SUSTAINABLE AGRICULTURAL DEVELOPMENT IN HUMID TROPICAL FOREST REGIONS OF CENTRAL AND SOUTH AMERICA

SEPTEMBER 19, 1984

Mr. Chairman, it is a pleasure to appear before your Subcommittee today to discuss sustainable agriculture development in humid tropical forest regions of Central and South America. I am Walter Parham, Program Manager of the Food and Renewable Resources Program of the Congressional Office of Technology Assessment (OTA).

This year, OTA completed a study for the Congress entitled Technologies to Sustain Tropical Forest Resources, a study that examined wet and dry tropical forest regions worldwide. Much of the material contained in my testimony comes from the parts of the report that dealt with hot, wet tropical lands and from related OTA studies.

Forest losses in the wet tropics largely are related to agricultural land clearing for shifting cultivation and for cattle raising. The ability to sustain these agricultural practices is linked closely with the ability to maintain soil fertility. In the hot, wet tropics this is a major problem.

Although the soils on certain tropical deltas, geologically young volcanic materials, and flood plains may be fertile, most soils in hot, wet lands have significant fertility problems. For example, only about 6 percent of the Amazon Basin's soils have no major limitations. High temperatures and high rainfall combine to accelerate leaching of nutrients from the soil. The

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residual soil minerals are composed mostly of aluminum, silicon, iron, oxygen, and water, a chemical composition so restricted that many food or tree crops planted here will have stunted growth or will not survive.

Infertile tropical soils by themselves are not a direct cause of deforestation. They do, however, set the stage for the practice of shifting cultivation. Shifting cultivation techniques are similar everywhere: farmers fell and burn the woody vegetation to release their nutrients to the soil; then cultivate the ground for 1, 2, or 3 years; and then abandon the site for a long period to forest or brush cover. The farmers clear a new patch of forest, plant crops and the process repeats itself.

Reasons for shifting to new fields include: decreasing crop yields, decreasing soil fertility, reduced soil moisture, pest outbreaks, or excessive weeds that raise labor requirements. Long fallow periods, perhaps 20 years, generally allow the land to recuperate and become productive once more. If such soils could sustain continuous agriculture, shifting agriculture would be less likely to occur and fewer forests would be cut down.

Even traditional shifting cultivation practices are breaking down under increasing population pressures. Commercial exploitation and subsequent colonization leave less land for traditional cultivators. With limited land and increasing populations, fallow periods have decreased. These shorter cycles do not allow enough time for forests to restore adequate soil fertility resulting in even more extensive forest clearance and a gradual decline in human living conditions. Farming on steep slopes is common in Latin America, Africa too, and Asia. Population growth often leads to increased clearance of forested watersheds and forces many farmers to migrate to mountain slopes, clearing forests as they go.

Cattle raising too plays a major role in the loss of tropical moist forests in the Brazilian Amazon and in Central America. The pasture area in Central America more than doubled between 1950 and 1975, almost entirely at the expense of undisturbed forests. Between 1966 and 1978, 8 million hectares of Brazil's Amazon forest were converted into 336 cattle ranches supporting 6 million head of cattle. In addition, some 20,000 other ranches of varying sizes have been established.

Pastures commonly are abandoned after 10 to 15 years of grazing because of declining soil fertility, erosion, soil compacting, invasion of unpalatable weeds, and low productivity. In parts of the Brazilian Amazon, ranches only 5 years old have failed because of pasture degradation.

One approach to maintaining soil fertility under agricultural practices, of course, is to add commercial fertilizers. This has been tried experimentally with certain success by soil scientists. Most farmers in these regions practice subsistence agriculture and, thus, probably are unable to finance the high cost of continuous fertilizer inputs. This is especially true in the Amazon Basin where 90 percent of soils have a phosphorus deficiency; 73 percent suffer from aluminum toxicity; 56 percent are low in potassium, only to mention a few of their limitations. Difficulty in obtaining, transporting and storing fertilizer adds further complications.

Moreover, the use of fertilizer may cause unexpected environmental problems such as increased plant growth in water bodies that can hamper navigation. Further, fertilizer additions may trigger the onset of new health problems. For instance, a large part of the Amazon River Basin has the required environmental conditions for the presence of schistosomiasis, a serious parasitic disease transmitted by freshwater snails. Chemical analyses of waters draining large forested areas here are nearly as devoid of nutrients

as is distilled water. It is suspected that the reason the disease is absent probably is because the waters contain so little calcium that the snails cannot build shells. Lime introduced to agricultural fields could move into nearby streams and rivers setting the stage for the spread of schistosomiasis. Fertilizers can be both beneficial and detrimental, so the impacts of various fertilizer applications need to be examined thoroughly before widespread use.

Agricultural researchers are paying increasing attention to designing low-input agricultural systems for all tropical regions as well as for the U.S. Low-input agricultural systems generally imply systems using plants and animals that benefit one another, that easily adapt to a particular environment, and that require minimal additional inputs (e.g. water, nutrients, pest control) rather than modifying the environment substantially to fit the plant and animal needs. In addition, scientists in recent years, have begun developing modern technologies to improve, rather than replace, the traditional farming systems. These modified systems face fewer cultural obstacles to their acceptance.

One such system is agroforestry, a low input agricultural system (see Table 1 for examples). Agroforestry encompasses all land-use practices that combine forestry, agriculture and livestock raising. Agroforestry is a new word, not a new concept. The novelty lies in formally recognizing that many different tree-based land-use practices possess certain common features that hold great promise in the Tropics. It's aim is to optimize ecological and economical interactions between the various plant and animal components to obtain a higher, more diversified, and/or more sustainable total production than is possible with any single land use. For example, some farmers plant

multipurpose trees that fix nitrogen, provide animal fodder, fuelwood and erosion control successfully with food crops, thus, providing the farmer with a range of agricultural goods and services.

Depending on the particular situation, agroforestry may:

- o increase and improve food production;
- o produce firewood and other raw materials from shrubs and trees for subsistence, local sale, and sometimes for export;
- o protect and improve the soil's productive potential, particularly on steeply sloping or unstable soils;
- o improve social and economic conditions in rural areas by creating jobs, increasing income and reducing agriculturally associated risks;
- o develop land-use systems that draw on both modern technologies and traditional local experience and that are compatible with the cultural and social life of the people concerned.

Some 300 million people today practice some traditional form of agroforestry in areas having serious physical and socioeconomic constraints. The problem of improving productivity and yet maintaining sustainability of their agriculture and agroforestry methods is more difficult than that of improving commercial agroforestry systems. Reaching subsistence farmers can be difficult, and where they can be reached, they need to be convinced that the new technologies are beneficial. The time between planting a tree and achieving significant yields may involve risks that some subsistence farmers feel they cannot take. It also can be difficult to convince land users to

make long-term investments when land tenure is uncertain. Subsistence agroforestry nevertheless holds great potential for improving land use but has urgent need for technology improvement.

The effort to organize and assess existing national and international experience in traditional agroforestry technologies and to identify promising technologies for further development is under way at the International Council for Research in Agroforestry (ICRAF) and elsewhere. Other institutions working on agroforestry systems are shown on Table 2. The ratios of international financial support for research in tropical agriculture, forestry, and agroforestry, respectively, roughly are 200:10:1.

Agroforestry cuts across several disciplines, thus requiring an integrated and multidisciplinary approach. Agronomists, foresters, ecologists, sociologists, anthropologists, and experts in other related disciplines have accumulated much data on various tropical mixed-cropping systems. Such information can become the foundation for research programs to explore ways to integrate low-input sustainable production of food, forage, and fiber needs on appropriate lands. However, communication or coordination among these disciplines has been insufficient to formulate an overall strategy for development of agroforestry technologies. Interdisciplinary research teams, investigating and demonstrating integrated farming systems, could help alleviate this constraint by creating interested constituencies within each discipline.

Although agriculture and forestry each carry on their own research, interdisciplinary research involving both is scant. Thus, so long as agroforestry funding is channeled primarily through forestry departments,

little hope exists to involve agriculture and forestry closely in strengthening's agroforestry research. A thorough rethinking and revision of the appropriate institutional home for agroforestry is needed.

Even though agroforestry and similar low-input agricultural systems seem to have untapped potential for sustaining agricultural production in the hot, wet tropics much is still to be learned about the various physical, biological and chemical mechanisms that foster sustained productivity. Yet, a world literature survey of 2,000 journals that cover a broad array of tropical ecological research shows that from 1979 through 1983 published studies in tropical ecology have decreased significantly (see attached article). In 1979, the total number of published tropical ecology papers was 415 (3 percent of the total ecology literature) but by 1983 the yearly total dropped to 160 (1 percent).

Multilateral development banks offer one opportunity to promote ecological research relevant to development of low-input agricultural technologies. Small research components could be added to multilateral development projects to investigate ecological requirements and impacts of projects, and this information could be disseminated broadly within the institution, to other development-assistance organizations, to the research community through the scientific literature, and to appropriate developing country institutions.

Through existing mechanisms, the United States has considerable influence over activities of multilateral development banks and U.N. agencies. However, the United States has not fully exercised its influence to promote low-input agricultural systems.

The U.S. has two basic mechanisms for influencing the policies and programs of multilateral development banks: through the U.S. Treasury Department's Office of Multilateral Development Banks and through U.S.

representatives to the banks. The Office of Multilateral Development Banks oversees administrative budgets and policy papers for the multilateral development banks. It also evaluates loans on the basis of legislated, political, and economic concerns.

The United States has representatives on the boards of directors of the multilateral banks. Voting rights are allocated in proportion to each nation's contribution to the bank's budget. The United States has 19 percent of the total voting power on the World Bank's Board, 5 percent of the African Development Fund, 13 percent at the Asian Development Bank, and 35 percent at the InterAmerican Development Bank. However, a formal vote is rarely taken because decisions on projects generally are made by consensus. The multilateral development banks can fund only those activities requested by governments; however, they can influence the kinds of programs that are undertaken by developing countries. U.S. representatives to multilateral development banks could be directed to encourage the funding of agroforestry and other low-input agricultural approaches.

In addition, other associated actions that U.S. representatives to the multilateral banks and U.N. agencies could promote include:

- o increasing emphasis during agricultural project design on the long-term sustainability of the agricultural production system,
- o improving monitoring and evaluation of agricultural projects to assure their long-term sustainability,
- o increasing the number of staff having interdisciplinary agriculture/ecology,
- o expanding the dissemination and publication of research findings from low-input agricultural projects.

Table 1

Some Prominent Agroforestry Systems in Developing Countries of the American Tropics

1. Agro-silviculture
    1. Trees in perennial cash crops (coffee, cacao, tea)
    2. Trees for organic matter and mulch with annual crops
    3. Tree live fences
    4. Windbreaks and shelterbelts
    5. Trees as support for climbing commercial crops
    6. Taungya
    7. Shifting cultivation systems
2. Silvo-pastoral
    1. Trees in pasture
    2. Pasture in natural regeneration forest
    3. Trees lopped for fodder
    4. Trees used for browsing
3. Agro-silvo-pastoral
    1. Agricultural plantation crops (coconut, rubber, fruit, trees) with crops and pastures
4. Home gardens

    various forms
5. Others

    mixed perennial cropping

Table 2

Organizations That Work on Agroforestry Systems

1. International Council for Research for Agroforestry
2. Centro Agronomical Tropical de Investigacion y Esenanza (CATIE)
3. International Tree Crop Institutes (U.K., U.S.A., and Australia)
4. Nitrogen-Fixing Tree Association
5. National Academy of Sciences (fuelwood and legume tree species)
6. Commonwealth Forestry Institute (information, research, and training)
7. East-West Center (dissemination and exchange of agroforestry information)
8. United Nations University (workshops and research programs at cooperating institutions)
9. Some components of UNESCO/MAB research program
10. Some developed country universities
11. Some CGIAR research institutions (e.g., IITA in Nigeria on alley cropping and CIAT in Colombia on Leucaena and Erytherina)
12. FAO's Panel of Experts on Forest Gene Resources

Nature, v. 309, p. 204, 1984

Tropical ecology research

SIR — The table below is compiled from the monthly listings of ecological publications in *Current Advances in Ecological Sciences* between 1979 and 1983. The journal (published by Pergamon, Oxford) cites an annual average of 15,000 recent ecological publications in about 2,000 source journals worldwide, under 56 major categories which I have condensed to 14 topics. The table shows a declining annual trend in tropical ecological research publications from 2.93 per cent of the global total for ecological publications in 1979 to about 1 per cent in 1983. The decline is also evident in each of the 14 areas listed except for tropical ecology (*sensu stricto*).

The major areas of research shown in the table are: (1) plant and animal interaction covering host/parasite relationships, competition and interaction of man and micro-organisms (24.2 per cent); (2) plant and animal communities — sociology, population dynamics and behaviour (14.0 per cent); and (3) growth, diseases and adaptation (11.3 per cent). Very little (0.2–2.4 per cent) tropical research work was done in (1) micrometeorology and the use of artificial environments for studying the functions of tropical plants and animals; (2) water relations and hydrology; and (3) the ecology of various tropical plant communities as ecosystems.

The above trends indicate that tropical ecological research has been utilitarian, with emphasis on topics of direct benefit to mankind especially for food production. However, in view of the spread of desertification — which now affects 34 countries in Africa — and the economic crisis caused by the prolonged drought during 1982–83 in more than 24 African countries, including some coastal countries in the wet tropics, I think that much more emphasis should be placed on tropical ecological research dealing with water relations, hydrology and climate.

What is responsible for the decline in tropical ecological research publications? Can it be due to the effects of the economic recession and inflation on research work at universities and governmental institutions in developing countries in the tropics? One trend which has been obvious during the period is the massive migration of seasoned university staff and scientific research workers from the poorer developing countries in Africa to the more affluent developing countries in Africa as well as to the industrialized countries outside the continent. This brain-drain may have contributed to the decline in ecological research work in the tropics; other factors may be the paucity of research funds and facilities, and of the trained middle level manpower needed to support field work.

N.H. AYODELE COLE

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Trends in tropical ecological research 1979–83

	1979	1980	1981	1982	1983	Total (%)
General tropical ecology (historical, biogeography, dynamics of ecosystems)	43	38	16	16	10	123 (9.5)
Plant and animal communities	57	41	43	16	25	182 (14.0)
Productivity and energy	29	16	10	7	9	71 (5.5)
Plant/animal interactions	111	94	55	22	31	313 (24.2)
Biogeochemical cycles and nutrition	18	11	11	9	6	55 (4.2)
Water and hydrology	5	4	4	5	3	21 (1.6)
Growth, diseases and adaptation	51	45	26	14	10	146 (11.3)
Autecology, genecology and crop ecology	29	30	18	12	10	99 (7.6)
Micrometeorology and artificial environment	1	1	0	0	0	2 (0.2)
Soil biology, erosion, humus and microbes	22	20	5	7	6	60 (4.6)
Environmental problems (hazards, conservation, wildlife, pollution; weed and pest control)	26	22	26	13	21	108 (8.3)
Land use, surveys, remote sensing and statistical sampling	16	8	6	3	7	40 (3.1)
Tropical ecology	2	0	4	18	21	45 (3.5)
Forest, grasslands, freshwater and microbial ecology	5	9	11	5	1	31 (2.4)
Total entries for the tropics	415	339	235	147	160	1,296 100
% Of total entries (all subjects)	2.95	1.59	1.97	0.62	1.09	

Associated OTA Studies

1984: Technologies to Sustain Tropical Forest Resources; OTA, U.S. Congress, 344 p.

1983: Reforestation of Degraded Lands; Background Paper No. 1 of Technologies to Sustain Tropical Forest Resources; OTA, U.S. Congress, 55 p.

1983: U.S. and International Institutions; Background Paper No. 2 of Technologies to Sustain Tropical Forest Resources; OTA, U.S. Congress, 65 p.

1983: Plants: The Potentials for Extracting Protein, Medicines, and Other Useful Chemicals; Workshop Proceedings, OTA, U.S. Congress, 252 p.

1981: Innovative Biological Technologies for Lesser Developed Countries: Background Papers; OTA Workshop Proceedings, Committee Print, Committee on Foreign Affairs, U.S. House of Representatives, 511 p.

Mr. SCHEUER. Well, Mr. Parham, your testimony was extraordinarily interesting. We appreciate it very much.

Mr. Lovejoy, please proceed for 5 or 6 minutes, and then we'll have some questions, I'm sure, for the two of you.

Mr. LOVEJOY. Fine. Thank you for this opportunity to testify on this important topic.

The U.S. World Wildlife Fund is the major organization working in conservation, private organization, in Latin America——

Mr. SCHEUER. Could you pull your loudspeaker a little closer, please?

Mr. LOVEJOY. Sure. And by way of my own credentials, this is my 20th year working on ecological problems in the Amazon.

I thought I might begin with a Brazil nut. This is what actually grows on the tree. About 50,000 tons of them come out of the Amazon every year. It's a very important export for Brazil, and every single one of them is a forest extraction product. The ecology of its pollination is such that up to this point nobody has pursued trying to grow them as a plantation crop. And by itself, it illustrates the kinds of problems that we're dealing with in development in these regions.

I would like to comment briefly on the Polonoroeste project, not in the detail that has already been gone into and will come up later, but rather, as an example of development projects and what we might learn from it.

I was very much involved with trying to guide the development of that project some years ago, with the various ecological elements in it, money for research of a wide variety, and I really must say that I felt the bank officials I was dealing with at the time were very conscientious from these points of view. Where this project has failed in the largest part is in the actual implementation of all of that. And while it's easy to be critical of the Brazilian Government, it's also a little bit like thinking of our transcontinental railroad project of the last century being funded by a development bank.

There are very serious problems just of control of all sorts in the Amazon. It's a vast territory. What is lacking here are institutional capacities, say the National Park Service or the Forestry Service of Brazil, to really cope with these problems on any meaningful scale. It suggests to me that those agencies involved in international development should be thinking of specific projects to strengthen these institutions, not just with respect to an individual development project here and there, but with regard to the overall capacities for sustainable, wise development throughout these nations.

It is also important—and it is less relevant to this project, but it certainly shows up in many others—to have the environmental offices and officers in these agencies occupy stronger positions. It's very difficult for the environment office at the bank to really guide all the development of projects. It's a little bit like swatting at passing flies. They have so many responsibilities and are so low down in the hierarchy.

There are also some problems that I believe that are of such a large nature that they're only approachable by big projects or World Bank kinds of finance. I think particularly of the problem of the slash and burn farmer who makes little impact when popula-

tion densities are low, but when they increased in numbers has a very severe impact. And trying to provide a different way of life for a slash and burn farmer is a very complicated project. If he goes to a cash crop, he has to be able to turn that cash into food or whatever. He has to be able to turn his product into cash. They're big projects all around.

I was asked to speak a bit about research needs. Most of the research needs are already known. Here's a report from the National Research Council on research priorities in tropical biology, a national academy one on the ecology of development in the humid tropics, and an OTA report that we've just heard referred to.

One of the most important things to recognize is that these are some of the least known areas biologically in the world. Just 2 hours drive from Manaus, a city that's been there 300 years, which is the seat of the Amazon Research Institute, I have a research project which is turning up new species—not obscure, but large things like trees all the time. This is a new species of trees that turned up. And 2 weeks ago a World Wildlife Fund expedition turned up a new form of rubber tree within 2 to 3 hours drive of Manaus. What that could mean for world rubber production we don't know yet, but its important stuff to have to be working with.

The most important research that we can undertake is to do some basic biological inventory, to find out what these hundreds of thousands of undescribed species are and where they are, so that we can plan development to avoid their extinction. Obviously we need to look at ways to use the forest on a sustainable basis, look at agroforestry in a more detailed and organized fashion, and indeed, to think about doing implementation projects, because it's one thing to do a little pilot project, it's another thing to actually bring it to a marketable crop.

We need to do a lot more research on topics like how the Amazon forest creates half its own rainfall, because although we can say that the forest does produce half its rain, science today cannot tell you what you can do to the forest without disturbing that. It can tell you a couple of obvious things not to do, but it doesn't tell you how to live with it and maintain it.

With respect to the discussion earlier about the greenhouse effect, I would make the point that the tropical forests of the world hold a pool of carbon equal to half of that in the atmosphere, and so it immediately becomes obvious what their wholesale destruction could mean to the overall climates of the world.

We need research on how to take degraded lands and turn them back into use. Most of the tropical timber needs of the world could be met if we did that. That immediately takes pressure off the forest. We need to look not only at the minimum size for conservation areas, which is my own particular research interest, but at its inverse, what does the size of a clearing say about its sustainability and the ability of the forest to recover.

We need——

Mr. SCHEUER. I take it you're inferring that its sustainability goes in inverse proportion to its size.

Mr. LOVEJOY. Well, certainly its ability to recover does. And I suspect——

Mr. SCHEUER. Also, its ability to survive in harmony with the rain forest.

Mr. LOVEJOY. Well, our experience to date would indicate that.

Mr. SCHEUER. You would buttress Mr. Lutzenberger's testimony on that point?

Mr. LOVEJOY. Yes, indeed.

We also are very often unable to be very precise about how fast it's going, where it's going fastest, and what has been going on in terms of our remote sensing capabilities. The transfer of the Landsat program and its commercialization is going to have a severe impact on our ability to keep track of these things, and indeed, what changes in use of the land around the world will be doing to our climates. So I draw your attention respectfully to what has been happening with the remote sensing capabilities of the United States.

Mr. SCHEUER. As you know, this committee has been a very determined protector of the remote sensing capability.

Mr. LOVEJOY. I do. I just wanted to——

Mr. SCHEUER [continuing]. The process of——

Mr. LOVEJOY [continuing]. Reinforce that.

Mr. SCHEUER. We have fought tooth and nail to continue it, and we've emphasized, as recently as yesterday, the importance to our foreign policy of identifying these various ecological changes and environmental changes that are taking place around the world, and continuing our Earthsat program to disseminate on a regular, daily, even hourly basis this vast flow of information as we pickup for the benefit of maybe 120 developing world nations that are getting it on a complementary basis from us.

Just yesterday the administration changed its mind. Apparently they had reservations about continuing the two satellite orbiting system that was giving us this continuous flow of information with a backup capability there in case one satellite konked out, as happened recently, so you're talking to some very determined protectors of that, of that capability.

Mr. LOVEJOY. I think it is one of the most important things we can do in managing our planet wisely.

I would like to also say that it seems to me that it is, indeed, very much the business of these development agencies to be concerned about establishment of strictly protected areas around the world, so we have a representative series of ecosystems and the full variety of plant and animal life preserved for our use, for posterity. And it's not only a matter of thinking of them as a resource bank; they also really represent an international bureau of ecological standards. They are our best means of measuring how we are using the rest of our landscape. They are a basic source of knowledge about our relationship with biology.

To sum up, I would like to focus on the difficulties of developing nations in being able to implement all these protection measures, a difficulty which has been heightened by the international debt problem. As I listened to the discussion of the push to grow soy in Brazil, the push to grow cane for alcohol, it immediately is obvious that all of that is related to the international debt, because Brazil needs that foreign exchange. Every time the prime rate rises, they owe another $1 billion that year.

And I would like to propose consideration of some form of credits on that debt, akin perhaps to the Public Law 480 moneys, which could be devoted to resource management and protection in these countries, in related training, research, and so forth. Not only would it provide a bit of a face-saving way of dealing with what is close to financial grid lock, but also it could feed into the economies of those countries at the same time, much as our Civilian Conservation Corps did some years ago. So I raise the international debt both as a set of problems of environment in itself, but also I would hope perhaps the seeds of some of its solution.

Thank you very much.

[The prepared statement of Mr. Lovejoy follows:]

TESTIMONY OF THOMAS E. LOVEJOY
VICE PRESIDENT FOR SCIENCE, WORLD WILDLIFE FUND-U.S.*

BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT
UNITED STATES HOUSE OF REPRESENTATIVES

19 September 1984

Mr. Chairman and members of the Committee:

I am here today representing the World Wildlife Fund-U.S., the largest private international conservation organization in the world. The United States World Wildlife Fund has major involvement in the support of research in Latin America. It is a pleasure to appear before you today to testify on recent agricultural development projects in the humid tropical forest regions of Central and South America.

The world, particularly the emerging nations, are in a rush to develop. For many of these countries this is seen as the only solution to burgeoning populations and attendant social and economic problems. Indeed, the World Conservation Strategy explicitly recognizes the need for development and its importance to conservation. Stated starkly one can hardly expect a caboclo or campesino worried about his family's next meal to concern himself about genetic resources or national parks. Indeed it is hard for him to even worry deeply about the sustainability of his use of the land: if the family must move on and clear another patch of forest for but three years of yield, then so be it, as long as the

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* Chairman, Tropical Forest Working Group, International Union for the Conservation of Nature and Natural Resources (1981-present); Principle Scientific Advisor, WNET (Channel 13, New York) "NATURE" series (1980-present

family's immediate needs are met. The environment and suitable uses of the lands and waters are more likely to be considered once standards of living have reached a minimum level.

The World Conservation Strategy also spoke to the other side of the development issue, namely that there can be no healthy development without a proper sustainable ecological basis. Today, in the age of the large development project this takes on particular meaning. These projects are inherently difficult just by nature of their scale and the limited institutional capacities of the developing nations to cope with potential problems. The situation is not all that different from our own Transcontinental Railroad project of the last century in its law-of-the-gun wild west context and the land rush that it triggered. Land was misused. Native peoples were treated terribly. It is our good fortune that the soils generally were rich and the ecology more capable of resisting the pressures put upon it.

While I would not minimize the probelms developing countries face, it certainly is clear that we know a great deal more in 1984 about what needs to be done and what should not than a century or more ago. We know from the experience of the TransAmazon colonization scheme that these projects can be done poorly. Can they be done well? It should be possible to do better than has frequently been the case. There are obviously difficulties with big projects: the institutional capacities for controlling immigration, protection of indigenous peoples, fomenting appropriate land use practices and protection of the environment can be seriously strained or surpassed. These kinds of problems in theory can be accommodated by including project elements to strengthen institutional capacities. This has been done, on occasion, but sometimes these elements

have not measured up in practice to their promise on paper.

There is no real reason this cannot be achieved. The big Carajas iron ore development project in the southeastern Amazon makes the case. It neighbors an area of virtual lawlessness surrounding the Serra Pelada gold strike where the panners for gold have left the landscape looking like a prairie dog town. The environmentally disastrous Tucurui hydroelectric project is not far away. The Companhia Vale do Rio Doce (CVRD) which manages the project area of hundreds of thousands of hectares and a 600 kilometer railroad to the Atlantic has not only been very careful in its planning from an environmental point of view (only 1% of the land has been deforested) it has also implemented these goals effectively by providing appropriate living conditions for workers and surrounding inhabitants as well as providing protection. Early next year World Wildlife Fund and CVRD will jointly sponsor a workshop at Carajas to study the problem of how to use the tropical forest without destroying it. CVRD may well implement pilot projects based on the results. The CVRD area is on its way to becoming an isolated area of Amazon forest managed for development in an exemplary way. It does indicate that where there is a will (and the resources) there is a way. There is no reason for development agencies not to provide the resources; the problem is how to work with host countries to achieve both the will and the institutional means. It also suggests that Development Banks support specific projects to develop institutional capacity to manage development, so these nations can better manage their development no matter who is paying.

As someone who has put in twenty years by next June on research, conservation and development in tropical America, it is very clear that even if institutional capacities are brought to an appropriate level,

that there is a severe problem of lack of knowledge. This is not surprising since the tropics contain half or more of all species. Indeed it is the common experience of those working in the tropical forests of the New World, to find species unknown to science. In the Minimum Critical Size of Ecosystems study areas where my Brasilian and American colleagues and I are working near Manaus (one of the two best explored regions of the Brasilian Amazon), we are finding new species. These are not just obscure forms, they include trees - rather conspicuous organisms! - and half a dozen new species of frogs. The perennial corn discovered a few years ago in Mexico is an excellent example of the potential economic importance of unknown species.

Any impressions to the contrary from the OTA report just published in March of this year, considerably more basic research is needed. Biologically, tropical forests are some of the most poorly explored regions on the face of the planet. With environmental destruction proceeding at full tilt, biological exploration and inventory work is needed to avoid extinctions on a very large scale and provide a sound basis for land use planning. While some of this work is being underwritten by the National Science Foundation, the traditional and basic science agencies cannot meet the need. What ideally is needed is a modern neotropical equivalent of the old U.S. Biological Survey. There is a great deal of vitally needed research that simply will never be funded unless development agencies take the initiative. They might take the view that it is not their business, but I would assert that it very much is. They are the instigators of much development and its potential environmental ill effects. It can only be environmentally sound if they put substantial resources into such science.

There is a shortage too of trained technical people not only in developing nations but also generally. So there must be accompanying money for training if the scientific goals are to be realized.

The necessary work is more than what is in a sense old fashioned biological exploration. There are serious environmental topics that need adequate study. We know from the work of Eneas Salati and others from Brasil that the Amazon forest generates half of its own rainfall, and that changing the vegetation may alter rainfall patterns in the Amazon and the adjoining portions of Central Brasil. Such changes may have implications for global climate patterns. A large research project has been carefully planned to examine the details of the hydrological cycle of the Amazon, and to get at the critical development questions of what combinations of different land uses are possible without disturbing the integrity of this fundamental aspect of Amazonian ecology. So far the United States has not found the necessary funds to contribute to this project.

World Wildlife Fund-U.S. and the private foundations (A.W. Mellon, Tinker and Sequoia Foundations) are currently supporting a twenty year project (see attached article from Science) that studies the deterioration of isolated pieces of forest subsequent to forest fragmentation. This has fundamental implications not only for national park design but also for almost any use of a forest fragment (woodlot, subsistence hunting, production of a forest product). The burden on the private agencies is heavy and would not have to be so great were development agencies supporting appropriate research.

Other necessary research is needed on ways to use these tropical lands, and in particular, of course, tropical forest lands. It is now pretty clear that massive traditional agriculture and pasture projects

are not desirable, but rather that the emphasis should be on ways to use the forest or tree crops. One important way is for wildlife harvest. The Smithsonian Institution has an intriguing project on iguana production supported by the W. Alton Jones Foundation. World Wildlife Fund with support from that same institution has one on the Tupinamba lizard in Argentina and another on white tailed deer in Costa Rica. These are all topics the development banks and federal agencies should be supporting. The Fish and Wildlife Service has had a project to develop a research station for this purpose in Amazonian Ecuador which has languished unfunded for several years.

Many tropical soils - but not all - are limited in their agricultural potential, at least without expensive additions of pesticides and fertilizers not easily available to local farmers. A new volume entitled Amazonia: Agriculture Land Use Research, published by the Centro International de Agricultura Tropical in Cali Colombia suggests the maximun area of fertile soils is about 10%, that 80% are strongly acid and 75% have toxic levels of aluminum. Most traditional crops (until a tropical blueberry is developed) will not be successful under these conditions. Imaginative research is needed to identify appropriate crops including use of native species. The Babaçu palm for example can provide thatch for roof construction, edible nuts, a cooking oil, and charcoal; it is estimated 1500 kilograms of nuts could be produced annually per hectare. The Brasil nut need not remain a forest extraction crop.

Another critical topic is reforestation of already deforested and degraded lands. Frank Wadsworth of the Tropical Resource Institute in Puerto Rico estimates that if these lands were turned back into wood production that much if not all of the world demand for tropical timbers

would be met. Some research on Leucaena indicates it to be an important tree from this point of view, but the full roster of its plusses and minuses needs to be explored. Many other species should be investigated, particularly native species. Recently I visited the Tijuca forest behind Rio de Janeiro where I discovered this was a reforestation project using native species initiated in 1861.

Agroforestry is an important area of research for these regions because in some instances it leaves forest, even if modified, or otherwise a tree crop. It uses the "forest" ecosystem for crops of various sorts. AID is already supporting some specific projects but the efforts are fragmented institutionally and more support is needed.

Odd as it may seem, precise estimates of deforestation rates (and hence of forested and deforested) areas are lacking. Nobody denies the rates are high and the problem large, but a properly funded research program on this topic would be a great aid to better planning and use of the land.

One of the areas where a great deal of research investment is needed but where little is taking place is natural regeneration forestry. While plantation forestry is increasingly important and has research needs of its own, it is management intensive, and large areas of the neotropics will be left to forestry based on natural regeneration - if only we have the knowledge and experience upon which to proceed. The World Bank, for example, in a recent listing of forestry research projects, had no such activities.

It is of paramount importance that development proceed in the Americas accompanied by the establishment and protection of parks, reserves, and research areas. There is a long way to go before the full array of plant

and animal species and natural systems and communities are adequately protected. Such a system would, of course, protect the biological resources so important for human welfare. Devising a complete system will depend on biological inventory research, but it is important to recognize that these reserves themselves are fundamental to the progress of biological research and all its inherent benefits to society. It is useful and correct to think of such protected areas as a system of international ecological standards against which we can measure the effectiveness and the merits of management of the ecology of the land for production and other direct human uses. There can be no more important agenda item: without it the globe will be managed in an ad hoc fashion and with considerable ignorance; with it we can strive for a more scientific and rational approach. This is the essence of the Man and Biosphere (MAB) program which needs considerably increased support.

The rub, of course, is that the very countries where such protection (as well as other management) is so needed, are far from capable, financially and otherwise, of bringing it to pass. The international debt problem has worsened the situation. Belt tightening measures, and additional strictures from the International Monetary Fund, tend to undercut these programs even when time is of the essence.

The debt is not resolvable in ordinary terms. I would propose that the United States explore the possibility of instituting debt credits for natural resource protection and management products in these countries. Not only would proper environmental safeguards ensue, but also, in analogy to our Civilian Conservation Corps, the activities would contribute to the national economies and hasten the resolution of the rest of the debt. There is plenty of precedence for this in Public Law 480, and when projects are funded from that debt owed to private banks appropriate tax credits could protect their balance sheets.

In a sense the debt is testimony to the degree to which developing nations are tied to the United States, and how their problems - including those environmentally driven - can reach out and effect even this the most powerful of nations. What better solution than to turn the problem around and let it provide the solution?

Parks: How Big Is Big Enough?

A major ecological experiment in the Amazon rain forest addresses the crucial size question of national parks

The annual felling of some 11 million hectares of Amazon rain forest exemplifies the massive and pervasive environmental destruction that is occurring on a global scale in the bow wave of unrelenting development. It is therefore fitting that, on any geographical and temporal scale, the Amazon forest is also the site of the world's most ambitious environmental experiment, which is designed to determine how best to protect the dwindling habitat resources that remain.

The project area, which is located in northern Brazil and covers some 600 square kilometers, is now designated as a permanently protected entity, as announced in June by the country's environment secretary. "This means that our reserves will remain isolated and protected for at least 30 years, and maybe longer" comments Thomas Lovejoy, the project's co-director and World Wildlife Fund scientist. Herbert Schubart, of Brazil's National Institute for Amazon Research, is the study's second co-director. Data collected throughout that period will answer some questions on the optimum size of habitat reserves and will also have a bearing on theoretical debates that have been rumbling among academic ecologists for almost a decade.

Currently the study area contains seven isolated reserves: three measuring 1 hectare, 3 of 10 hectares, and 1 of 100 hectares. Ultimately there will be as many as 40 reserves, including some of 1000 hectares and one covering at least 10,000 hectares.

During the lifetime of this joint Brazilian–U.S. enterprise biologists from around the world will monitor the loss of plant and animal species—the ecosystem decay—throughout the 1 to 10,000 hectare range of reserves. "The small reserves will give us a quick and simple picture of what we might expect," explains Lovejoy, "whereas the larger ones should provide more sophisticated insights over a longer period. We expect the 10,000-hectare unit to be representative of unbroken forest, except perhaps for some very wide ranging species, such as the harpy eagle and the jaguar."

Ecologists can already predict that the smaller units will suffer more than the bigger ones: a generally positive relationship between habitat area and number of species contained has been known for more than a century. And fragmented habitats are known to lose species once they are isolated, but the rate of loss and the processes involved in the decay are unknown. In very general terms, the Amazon project is meant to go beyond simple quantitative measures of numbers of species at risk, and instead yield some information on the minimum size of reserve that is required to preserve the principal characteristics of the ecosystem, to maintain the biological integrity.

Many academic ecologists are deeply involved in conservation efforts worldwide, at least part of their role being to apply ecological theory to optimum design of reserves. Faced with the pace of economic development and habitat destruction, some of them wonder whether Lovejoy, Schubart, and their colleagues are doing the environmental equivalent of fiddling while Rome burns. "It is the rest of us who are fiddling," says

> "This is the only experiment in the tropics that has a major bearing on this conservation issue."

Frances James, an ecologist at Florida State University. "They are down there collecting data. This is the only experiment in the tropics that has a major bearing on this conservation issue." It is a matter of hard practical reality, however, that 30 years down the line the planning of many, perhaps most, national parks around the world will already be a matter of history.

Because fragmentation of once continuous habitats is a major environmental consequence of economic development, the question of the size of a potential reserve becomes important in considering the composition of the ecosystem that will remain. It is obvious, for instance, that a reserve can contain only those species whose area requirements are equal to or less than the total available. Species whose needs are greater will, in all probability, become locally, and perhaps globally, extinct.

In addition, the fact that any such reserve is in effect an "island" amidst an uninhabitable "sea" will also affect the long-term dynamics of the ecosystem. Species will be lost through time, through stochastic and other processes. And as immigration of species from elsewhere is likely to be small, the island inevitably becomes ecologically impoverished as time passes.

"Although one can make some reasonable generalizations about ecosystem decay—such as species at low population density will be at risk following habitat fragmentation and isolation, as will top carnivores and others with large foraging ranges," says Lovejoy, "one cannot predict what might happen to the ecosystem as a whole." A knowledge of the processes involved, which will be derived from observation of repeated patterns of ecosystem decay, will give an insight into the dynamics of the ecological community and might allow selective intervention in the management of habitats that are below the minimum size.

A fair number of studies have addressed the problem of ecosystem decay following isolation, but none has been prospective. The great strength of the "minimum critical size of ecosystems project," as the Brazilian–U.S. venture is called, is that it is the first time the effects of fragmentation and isolation will have been closely observed throughout the decay process. "It is beautifully designed," comments Jared Diamond, an ecologist at the University of California, Los Angeles. "It is unique in human history."

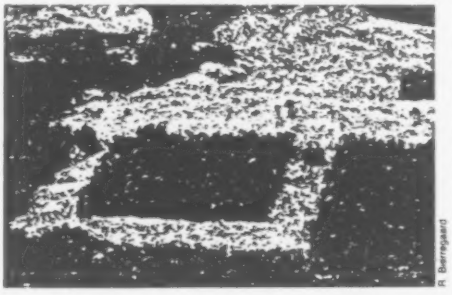
Lovejoy conceived the idea for the project at a time—1976—when ecologists were arguing over the application of island biogeography theory to the design of ecological refuges. The theory, which was developed in the late 1960's and was prominent in ecological thinking through the 1970's, addresses the equilibrium state of communities of particular sizes. It gives predictions of the number of species a particular type of habitat of a particular size might contain, given a balance between loss through local extinction and gain through immigration.

The arguments of the time came to focus on whether a large reserve would contain more species than several smaller ones of equal total area. Some contended that the theory could answer the point, whereas others countered that, in the real world, it was unhelpful.

"The trap with island biogeography theory," says Lovejoy, "is its simplic-

ity. It treats all species as being equal. Our aim is to get away from a simple quantitative assessment and address the ecosystem as a whole, as a functioning unit. Our goal is to try to determine what minimum critical size of reserve can protect the characteristic species composition of the habitat."

Each different habitat type has a roughly typical species composition, which has to do with diversity. For instance, 10 hectares of Amazonian forest will support some 300 species of trees, whereas diversity in a temperate forest is about one tenth that figure. "Each habitat type has a characteristic species/area curve, and, roughly speaking, the 'minimum critical size' is that which will protect the habitat's species/area curve, or something close to it."



R. Barrerpaard

Forest isolate

This 10-hectare reserve, isolated last summer, will eventually lose its neighboring forest completely. It is one of a planned 40 reserves in which the ecosystem decay curves will be determined over a period of 30 years.

To establish the minimum critical size for the rain forest habitat—for any habitat—two separate but related questions must be answered. First, are species lost in some sort of predictable order? And second, will forest fragments of similar size end up with similar final species compositions. The natural world is so very complicated that ecologists still cannot agree on whether there is "order" to ecological communities, whether they are structured units or random assemblages, which is why these two questions remain to be answered. As James notes, "the value of the Amazon project is that it will give an example of exactly what happens in a particular case." The outcome will be of both theoretical and practical import.

With two of the forest reserves being just 4 years old and the remainder less than one, there are no answers yet to these large questions. It is clear, though, that the loss of bird species proceeded more rapidly in the 1-hectare unit than in the 10-hectare reserve, which in general is what was expected. Eventually the project will yield a series of decay curves for each species group within each reserve size range. There should be enough duplicates within each size range to at least approach the question of randomness in species loss. And it should be possible to extrapolate through these four orders of magnitude (1 through 10,000 hectares) to a prediction of a minimum critical size.

During these first years of reserve isolation the focus of most folks' minds was, not unnaturally, the size question. It therefore came as something of a surprise when events forced attention to be turned to the phenomenon known as the edge effect.

The tropical rain forest forms for itself a highly insulated ecosystem—dark, cool, moist, often in the face of hot, dry winds. When a patch of forest is exposed to the elements, therefore, dramatic microclimate changes ensue which have had a much more dramatic impact than anyone had anticipated. In addition to encroachment by light-loving herbaceous plants, shrubs, and trees into the previous moist gloom, tree falls and drying out of leaf litter alters the edge habitat considerably. With these changes come concomitant shifts in animal populations. The penetration of this altered habitat has been surprisingly deep, with only a core of the 100-hectare reserve maintaining its characteristic butterfly community, for example.

"We have begun to devote a lot of attention to the edge effect," says Lovejoy, "and we've mounted a series of systematic studies on soil moisture, leaf fall, leaf litter, soil nutrients, as well as on air temperature and humidity." Once the magnitude of the edge effect has been established it can be discounted when calculations are made on the desired size of a reserve. "On the other hand, there will be plenty of small pieces of woodland under conservation around the world, and the edge effect would be dominant in these cases. We have to know about it."

This summer some 50 researchers have been going to and from the project site, continuing the monitoring of plant, animal, and insect populations in the planned and already isolated reserves. Already it is clear from the 4-year-old units that species with low populations—whether of birds or rodents—are particularly vulnerable to local extinction, which is no great surprise. The most numerous small rodent, *Proechimys*, also disappeared, which was a surprise. "We simply can't explain it at the moment." Fruit-eating saki monkeys could not find enough resource trees in their 10-hectare reserve and became extinct there. By contrast, a band of red howler monkeys, which live on leaves, are apparently sustaining themselves.

In a display of the connectedness of things, several species of ant-following birds, which prey on the fleeing victims of army ant colonies on the march, found 10 hectares too small a territory in which to survive: apparently there were insufficient active ant colonies to support them. And three species of frog have vanished from one reserve they previously occupied. The reason? They were dependent on standing water, which was provided by the wallow of the peccaries in the area. Along with other large mammals, the peccaries moved on when the reserve was isolated—the wallow dried up, and so did the frogs.

Each different habitat type is distinguished by the composition and diversity of the species it contains, and each can be expected to be susceptible in different ways and extents to the effects of fragmentation and isolation. Because of the great complexity of the Amazon rain forest habitat—its great species diversity and insulation, for instance—it is particularly vulnerable to ecosystem decay. Data from the Amazon project therefore cannot be expected to be completely transferable to other habitats. "Ideally, there should be a minimum size of ecosystem project in every habitat type throughout the world," notes Lovejoy. "In the absence of that we expect to be able to derive principles and patterns that can be applied elsewhere."

Diamond already sees one result that is directly relevant to conservation efforts in other parts of the world. "Government officials are always asking us, 'How big should our park be?' and 'How many species will we lose if it is only half that size?' and so on. Biologists have always sensed that large parks are necessary, but we haven't been able to back it up with strong evidence. The Amazon project is now providing that evidence. That is very important."—ROGER LEWIN

Mr. SCHEUER. Thank you, Mr. Lovejoy.

You dealt with that extensively in your testimony, giving points or credits to the countries that deal in an environmentally intelligent and sensitive manner with these problems. I was very much impressed when I read it.

I agree with the two of you so thoroughly I really don't have very much more in the way of questions. I've interrupted you a few times—I hope you'll excuse my interruptions—to ask you questions as they came up. We have benefited enormously, both from your written testimony and from your presentation here this morning, and we thank you very much. It was an excellent panel.

Mr. LOVEJOY. Thank you.

Mr. SCHEUER. We're grateful to you.

We will now hear the last panel this morning, Bruce Rich, representing the Natural Resources Defense Council, Barbara Bramble, representing the National Wildlife Federation, and Brent Millikan, advisor for the Foundation for Economic Investigation and Research of the University of Sao Paulo in Brazil.

We are delighted to have you here. Your full prepared testimony will be reprinted at this point in the record. We would also ask Mr. Jose Lutzenberger and Mr. Jorge Illueca to rejoin the table because I'm going to ask all five of you a couple of questions when the three witnesses have finished their comments, if they're still in the room. Mr. Lutzenberger. All right.

Just pull up a chair. We're going to do this very informally, Mr. Illueca.

All right. We'll start out with Bruce Rich, attorney for the National Resources Defense Council, and before he testifies, I want to thank him personally for the great deal of time that he has expended in the last 6 months or so in giving us of his counsel and advice and help in many ways, large and small, in putting this hearing together and in other, others of our projects. We are grateful to you for your past acts of kindness and courtesy, Mr. Rich, and we look forward for your testimony as well as the others.

Please proceed for about 5 minutes, and then when we finish the panel, I'm going to throw a couple of questions at all five of you.

STATEMENTS OF BRUCE M. RICH, ESQ., INTERNATIONAL PROJECT OF THE NATURAL RESOURCES DEFENSE COUNCIL; BRENT H. MILLIKAN, ADVISER, FOUNDATION FOR ECONOMIC INVESTIGATION AND RESEARCH [FIPE], UNIVERSITY OF SAO PAULO, BRAZIL; AND BARBARA J. BRAMBLE, ON BEHALF OF THE NATIONAL WILDLIFE FEDERATION

Mr. RICH. Thank you very much, Mr. Chairman. Thank you very much.

We're—I am very very grateful to you and this subcommittee, and I would like to thank you and the subcommittee on behalf of the six national environmental organizations on which I'm—on behalf of which I'm testifying today, for turning your attention to these important issues. I'm testifying on behalf of the Natural Resources Defense Council and five other environmental organizations, with over 650,000 members and supporters in the United States.

These organizations wish to express their grave concern today with the ecologically destructive nature of many of the agricultural development projects financed by the World Bank and Inter-American Development Bank in tropical forest areas of Latin America.

The World Bank and the Inter-American Development Bank are the two single most important sources of development assistance in the agriculture sector in Latin America. Although they disbursed in 1983 over $1.5 billion for agricultural development projects in the region, the actual cost of these projects, the total cost, was about three times greater because of cofinancing arrangements with governments and with private financial institutions.

Moreover, the policy influence in the agriculture sector of these two multilateral banks is really enormous, because many portions of their agricultural loans go for extension, research, training, technology transfer, and other forms of institution building, and, indeed, many countries actually modify their agricultural sector programs to better conform with the policies and suggestions of the multilateral banks.

Now, the agricultural lending of the banks has contributed substantially to the destruction of the region's irreplaceable tropical forest resources in two major ways: first, by helping to promote and implement general agricultural policies which are capital rather than labor intense and which have displaced large masses of rural farmers and the poor from better lands really suitable for agriculture into agriculturally marginal areas such as tropical moist forests. Mr. Lutzenberger said something about that, and Mr. Milliken who will follow me will also mention more about these policies. Of course, second, the projects of the banks directly contribute to deforestation, especially jungle colonization schemes, such as Polonoroeste,. and cattle and livestock schemes, which they have financed—which they have funded very substantially over the past 20 years. In fact, the World Bank, for the World Bank, perhaps as much as half of its total lending for agriculture has gone directly or indirectly for livestock in Latin America.

I have submitted for the record a number of documents which go into more detail on these issues. One in particular is an article which appeared in the spring, 1984 issue of Foreign Affairs, which discusses the links between agricultural development policy in tropical forest countries such as Brazil, deforestation and the role of the MDB's. This article describes the scenes of the devastation resulting from such projects as "reminiscent of photographs of Hiroshima." Well, that's obvious hyperbole, but it's significant that an article which describes these impacts in such vigorous terms has appeared in a journal as prestigious and important as Foreign Affairs.

A substantial body of scientific literature has emphasized that livestock development is one of the worst and most wasteful of all conceivable development alternatives for tropical forest regions. The economics of forest colonization projects is even more dubious. A decade ago a study of 24 colonization projects in Latin America noted that "few spheres of economic development have a history of, or a reputation for, failure to match that of government-sponsored colonization projects in humid tropical zones in Latin America."

A survey conducted by USAID in 1980 of six settlement projects in the Peruvian Amazon revealed settler desertion and abandonment rates ranging from 26 to 92 percent.

I have also discussed in my prepared statement the Polonoroeste program in some detail. One issue of particular concern is the highway that the Brazilian Government is completing through the Guapore Valley in the Rondonia area—that's the Highway BR-429. That was the highway which we saw pictures of the construction of in the film we witnessed earlier today. The construction of this highway and the settlement of 8,000 to 10,000 settlers in that area is a direct violation of two of the provisions of the loan agreement between the Republic of Brazil and the World Bank. And that loan agreement, among other things—in that loan agreement the Brazilian Government promised to the World Bank that it would discourage the agricultural exploitation of areas which have been determined to be unsuitable for agricultural development, or of areas whose suitability for agricultural development has not been determined.

The problems of multilateral lending in the agricultural sector are compounded by the fact that the banks have completely inadequate environmental research programs, and inadequate guidelines and environmental staffing for the environmental aspects of the agricultural projects in Latin America. That's also described in my prepared statement. I think it's significant that the World Bank, with nearly 6,000 employees, has only one professionally-trained ecologist, and indeed, he is the only person who is even sporadically looking at the prospective environmental impacts of these huge agricultural development projects.

In conclusion, Mr. Chairman, I have a number of recommendations which the organizations I represent respectfully suggest would enhance the already important oversight function which this subcommittee has brought to bear on these important issues.

One, we suggest that the subcommittee request the Treasury Department to obtain accounts from the World Bank and the Inter-American Development Bank concerning their research activities, current and planned, relating to the ecological impacts and aspects of agricultural development projects in Latin America, particular with respect to these destructive livestock and land settlement projects, and to prepare accounts of their research activities and support, current and planned, for some of the alternative agricultural models and systems which have been discussed today by the representative of the Office of Technology Assessment, and which are also discussed in my prepared statement.

Two, we think it would be useful particularly for the subcommittee to request the Treasury Department to obtain an account from the World Bank of what measures it currently plans to undertake to deal with the enormous environmental problems that are plaguing its half-billion dollar investment in the Polonoroeste Program, and also to obtain a response from the World Bank concerning how it plans to learn from this ecological disaster, what measures it plans to undertake to insure that it will not be involved in huge jungle settlement projects of this kind in the future.

Three, to send to the Treasury Department—through the Treasury Department to the World Bank and Inter-American Develop-

ment Bank, for comment, the testimony of the witnesses today who have discussed the agricultural research projects or policies of these institutions.

And our last suggestion is that we think it would be very productive to have hearings next year on the ecological and environmental aspects of agricultural development projects conducted by the multilateral banks and other institutions in Africa and Asia. Africa in particular is facing enormous environmental problems, some of which have been exacerbated rather than helped by the kinds of development projects in the agriculture sector which have been funded.

In concluding, Mr. Chairman, and members of the subcommittee, the organizations I represent wish to express their great appreciation for your holding these hearings which have delved into issues of tremendous importance for all who are concerned with the prospects for sustainable economic development and conservation of natural resources in tropical forests in Latin America.

Thank you very much.

[The prepared statement of Mr. Rich follows:]

STATEMENT OF

BRUCE M. RICH

ON BEHALF OF

NATURAL RESOURCES DEFENSE COUNCIL, INC.
ENVIRONMENTAL DEFENSE FUND
ENVIRONMENTAL POLICY INSTITUTE
FRIENDS OF THE EARTH
IZAAK WALTON LEAGUE OF AMERICA
NATIONAL AUDUBON SOCIETY

I. Introduction

Mr. Chairman, I appreciate very much the opportunity to testify before this Subcommittee concerning agricultural development projects in Latin America and their impacts on tropical forests. I am Bruce M. Rich, an attorney with the International Project of the Natural Resources Defense Council, Inc. (NRDC). I am testifying today on behalf of six national environmental organizations: the Natural Resources Defense Council, Inc., the Environmental Defense Fund, the Environmental Policy Institute, Friends of the Earth-U.S., the Izaak Walton League of America and the National Audubon Society. Together, these organizations have over 650,000 members and supporters in the United States. The Natural Resources Defense Council has over 40,000 members, the Environmental Defense Fund, 47,000, and Friends of the Earth-U.S., 35,000. The Izaak Walton League has 45,000 members and the National Audubon Society over one half million. The Environmental Policy Institute is a non-membership, non-profit environmental organization concerned with sound management of agricultural and water resources.

The six national environmental organizations I represent today wish to express their grave concern with the ecologically destructive nature of many agricultural development projects financed by the World Bank and Inter-American Development Bank (IDB) in tropical forest areas of Latin America.

My testimony this morning will focus on the agriculture sector lending of the World Bank and Inter-American Development Bank in Latin America and identify the relation of certain kinds of agricultural development projects financed by these institutions to accelerated deforestation in that region. My focus on these two multilateral development banks (MDBs) arises from the fact that no institutions have more influence in Latin America on agricultural development projects and policies; and from the fact that the U.S. can promote changes in the World Bank and IDB through its vote and voice on their Boards of Directors.

I will then discuss examples of agricultural development and research which a growing body of scientific research and opinion suggests could provide ecologically sustainable alternatives to the often destructive kinds of projects that multilateral development banks are still financing in Latin America. I will conclude with specific recommendations for actions the Subcommittee could take to generate further information on these critical issues and to promote changes in the agricultural research and development priorities of the World Bank and IDB.

II. Agriculture Sector Lending in Latin America by Multilateral Development Banks

A. Importance of the Agriculture Sector in the MDBs

The World Bank and Inter-American Development Bank are the two single most important sources of development assistance in the agriculture sector in Latin America. They disbursed in 1983 loans and credits totalling 1.03 billion and 0.49 billion dollars, respectively, for agricultural development projects in the region. For the World Bank in particular, agriculture has been its most important lending sector in Latin America for many years, accounting for nearly 30% of total Latin American lending in 1983. For the IDB agriculture is the second most important lending sector for the period 1961-83, accounting for 22.2% of culmulative loans. Recently the importance of agriculture has diminished somewhat, accounting nevertheless for a substantial 16.1% of its total 1983 loans.

These considerable dollar amounts greatly understate, however, the influence of these two institutions on agricultural policy and research in Latin America. For one thing, for every dollar the IDB lends out it attracts nearly three extra dollars through co-financing arrangements; as of December, last year, the IDB's culmulative lending amounted to some $25 billion for all sectors, but the total cost of the projects financed was over $91 billion. Assuming that the agriculture sector attracted the same average amounts through co-financing, the total cost of IDB agriculture projects in this period was over $20 billion. The World Bank attracts about two dollars through co-financing for every dollar it lends out. The Bank's culmulative lending in 1983 for agriculture in Latin America totalled $6.38 billion; the total cost of the agriculture projects it has financed in Latin America may well be over $19 billion.

The policy influence of these loans is increased by the fact that significant portions often go for extension, research, training, technology transfer and other forms of institution building. Finally, many countries, especially smaller ones, experience considerable pressures to directly modify and orient their agricultural development priorities to harmonize more closely with those of the MDBs. This kind of direct policy leverage is becoming increasingly important in MDB operations, especially in the case of the World Bank, where so-called 'non-project' lending has taken the form of 'structural adjustment' and 'sector' loans which seek to promote policy changes in whole sectors, such as agriculture.

B. Loans for Livestock Development and Agricultural Colonization and Settlement Projects

The MDBs have promoted on a massive scale certain categories of agricultural projects which often have directly led to accelerated deforestation and severe environmental deterioration; Two kinds of agriculture projects with particular ecological significance are livestock and agricultural settlement projects.

World Bank culmulative livestock project loans to Latin America totalled $1.02 billion in 1983, or more than 16% of the Bank's total agricultural lending in the region. But this figure greatly understates the Bank's involvement in promoting livestock, since loans categorized as agricultural credit, area development, agroindustry, and research and extension often had important livestock components. The Bank lent out nearly a billion dollars in agricultural credit projects to Latin America through 1983, and about one third of all agricultural credit lending went (at least through the 1970s, for which statistics are available) for livestock production. According to one estimate, more than half of the World Bank's culmulative agriculture lending in Latin America through 1980 went for livestock projects or projects with a livestock component. (Cheryl Payer, The World Bank, A Critical Analysis, Monthly Review Press, 1982.)

IDB involvement in livestock programs has also been extensive, especially through agricultural credit loans.

A review of World Bank and IDB lending for the past three and one half years indicates that these institutions are continuing to prepare and approve substantial projects and programs involving agricultural colonization affecting pristine forest areas and promotion of livestock development.

The biggest of these programs by far is the World Bank's Brazil Northwest Development Program, for which the Bank has approved six loans totalling $443.4 million since 1981; the total cost of this mammoth Amazon colonization, settlement consolidation and road construction scheme approaches $1.6 billion. In its past fiscal year the World Bank approved a loan to Panama, for the third of a series of Bank financed livestock projects, and a $25 million loan to Paraguay for that country's seventh Bank financed livestock project. In 1982 the World Bank approved a $42.7 million loan to Brazil for rural development and agricultural settlement in Brazil's Maranhao state, which risks worsening the deforestation and ecological destruction caused by a previous Bank financed project in the same region, the Alto Turi Settlement Project. The Bank approved loans in 1983 and 1981 to Paraguay for $40 million and $30 million, respectively, to

provide agricultural credit, extension and technical assistance with a substantial emphasis again on livestock development. It approved loans of $130 million (1983) and $40.6 million (1982) to Peru for agricultural credit, research and extension, again with significant livestock components. Agricultural credit loans to Mexico in 1982 for $175 million and in 1981 for $325 million also had significant livestock components.

In 1983, the Inter-American Development Bank approved loans of $35.8 million and $5.3 million to Costa Rica for livestock development and animal health projects, as well as a $130 million farm and livestock credit loan to Mexico and a $30 million agricultural research loan to Venezuela with a substantial livestock component. Loans of $32 million to Bolivia for agricultural credit in 1982, and in 1981 of $24 million to Costa Rica, $36.53 million to the Dominican Republic, and $20 million to Guatemala (for livestock health programs), all had substantial or predominant livestock components. The IDB also approved two loans totalling $46 million in 1982 for a jungle roadbuilding and colonization scheme in the Peruvian Amazon.

III. Connection of MDB Agricultural Projects to Ongoing Destruction of Tropical Forest Resources in Latin America.

The agricultural lending of the multilateral development banks in Latin America has contributed substantially to the destruction of that region's irreplaceable tropical forest resources in two major ways: first, by helping to promote and implement general agricultural policies which are capital rather than labor intense and which have displaced large masses of rural farmers and the poor from better lands suitable for sustainable agriculture into agriculturally marginal areas such as tropical moist forests; and second, through projects which directly contribute to deforestation, e.g. jungle colonization schemes.

Several witnesses this morning have, or will discuss the connection between the kind of capital intense, export oriented agriculture that has been promoted in Brazil and Central America and the migration of landless rural people into tropical forest areas. Rather than go into great detail myself on this question, I wish to submit for the record, with your permission Mr. Chairman, an article from the Spring, 1984 issue of Foreign Affairs which discusses the links between agricultural development policy in tropical forest countries such as Brazil and Indonesia, deforestation, and the role of multilateral financing institutions such as the World Bank: "Tropical Deforestation," Nicholas Guppy, Foreign Affairs, Spring, 1984.

The author, Nicholas Guppy (former Conservator of Forests in British Guyana), notes that "today, almost everywhere, destroying rainforest is a means of avoiding tackling real problems by pursuing chimeras...."(p.932) He notes that:

> ...though much forest colonization is spontaneous, more often it proceeds with government encouragement, as it provides a convenient safety valve for land hunger and social discontent. Almost none of it, however, is occasioned by a genuine shortage of land....In Brazil, outside of Amazonia...there is enough good, permanently cultivable land to give...ten acres to each [Brazilian] familiy--more such land than there is in the United States. Yet as a result of government policies disadvantageous to small farmers, small holders are selling up and moving elsewhere (in Parana state 40 percent of the smallholders of just one municipality left in 1982). Fifty percent of farmers [in Brazil] own only three percent of farmland, while 43 percent of farmland is owned by one percent of farmers. Many of the larger holdings of de-peopled high quality farmland, which are mostly in southern Brazil, are today underused, or even unused, being held for investment by corporations and absentee landlords whose main business is elsewhere. And ironically large tracts of this farmland are now being commercially reforested. Brazil thus has a real problem of land hunger in the midst of plenty. Foreign Affairs, Spring, 1984, pp. 939-40.

The Foreign Affairs article is particularly critical of the World Bank for its financing of huge forest colonization projects in Brazil and Indonesia. It describes the scenes of devastation resulting from such projects as "reminiscent of photographs of Hiroshima;" such government policies and projects, the article adds, "might be regarded as waging the equivalent of thermonuclear war on their own territories." (Ibid., p. 943.)

Cattle projects--which have been financed on a large scale by the MDBs (see Part II of this statement) over the past twenty years in Central America and South America--have contributed markedly to accelerating deforestation, both indirectly and directly. In many areas, large, consolidated cattle ranches have replaced smaller, subsistence oriented farming on soils suitable for perennial agriculture, contributing greatly to land concentration and the migration of the uprooted rural population to tropical forest areas. In other regions, pristine tropical forest has been converted on a massive scale to cattle pastures.

A substantial body of scientific literature has emphasized that livestock development is one of the worst and most wasteful of all conceivable development alternatives for tropical forest regions. (see, for example: Goodland, Robert J. A., "Environmental Ranking of Development Projects in Brazil," Environmental Conservation, Vol. 7, No. 1, pp. 9-25; Fearnside, Philip, "Cattle Yield Prediction for the Transamazon Highway," Interciencia, No. 4, 1979, pp. 220-225; Parsons, James J., "Forest to Pasture: Development or Destruction?," Rev. Biol. Trop., No. 24, 1976, pp. 121-138.) Pastures in former tropical forest areas often become wasteland after a few years because of declining soil nutrients, invasions of toxic weeds and soil compactation. In addition, livestock projects generate very little employment compared with most other investment alternatives.

The role of multilateral financing institutions has been critical in furthering livestock development in many instances. Parsons notes that "in the drive to diversify exports, government has encouraged an expanding cattle industry, and international agencies have given further support. -Especially decisive has been the availability of low cost credit. In Costa Rica, for example, nearly half of all agricultural credit in recent years has been to the livestock industry." (Parsons, op. cit., p. 126) He notes that

> "Such development oriented international organizations as FAO and IBD seem to forsee a kind of mixed farming as the optimal ultimate use...for [much of] the high rainfall Central American forests....There is a vision, it seems, of an isthmus converted to cropland and grass from the Pacific to the Atlantic. In Nicaragua a model for this is the 70,000 ha. Colonia Rigoberto Cabezas project on the La Gateada Nueva Guinea road souoth of the Rama road, recently funded by an $80 million IBD loan." Parsons, op. cit.,p. 127.

In the Brazilian Amazon, huge tax holidays and fiscal incentives up to recently made ranching attractive even in the face of poor and declining productivity of lands cleared for pasture.:

> "subsidized credit, and the role of ranching as a vehicle to capture enormous fiscal incentives meant that the primary value of Amazonian ranching land was not for production but exchange. In such a context there is little economic rationality in careful land management, but great advantages in controlling as much land as possible." Hecht, Susanna, "Cattle Ranching in

the Eastern Amazon: Environmental and Social Implications," The Dilemma of Amazonian Development, Moran, Emilio F., ed., pp.155-183, 1983.

In fact, during the 1970s, 70% of the cost of livestock development was subsidized by the Brazilian government, and this subsidization accounted for nearly half of that government development funding in Amazonia in that decade (Goodland, op. cit.).

The economics of forest colonization projects is even more dubious. A decade ago, a study of 24 colonization projects in Latin America noted that

> few spheres of economic development have a history of, or a reputation for, failure to match that of government-sponsered colonization in humid tropical zones [in Latin America]. Horror stories about about expensive ventures that resulted in colonies where few if any settlers remained after several years. The evidence is irrefutable, and failure can be attributed ongly to the institutions responsible for selecting the area and the colonists, planning and executing the development program, and subsequently maintaining or abandoning the infrastructure and services in the region. Nelson, M., [The Development of Tropical Lands: Policy Issues in Latin America, 1973, p. 265, quoted in Van de Laar, Art, The World Bank and the Poor, 1980, p. 178.

A survey conducted by U.S.A.I.D. in 1980 of six settlement projects in the Peruvian Amazon revealed settler desertion and abandonment rates ranging from 26% to 92%; three of the six projects had been virtually abandoned by their intended 'beneficiaries.'(Bunin, Nina M., "Colonization Systems Analysis: Review of Colonization Projects in the Peruvian Selva," Annex C, Vol. I, Project Synthesis Paper, Central Selva Natural Resources Management Project, U.S.A.I.D. Project No. 527-0240, 1981.)

In addition to the extraordinarily risky nature of tropical settlement projects, their cost per settler family, or 'beneficiary,' seems truly outlandish. The average investment per 'beneficiary family' for eight World Bank settlement projects implemented during the 1970s was, in 1975 dollars, $8901.25, or more than $18,000 a family in current dollars. ("Agricultural Land Settlement," World Bank, 1978, p. 56.) Incentives and investment per settler in the Polonoroeste Program total over $12,000.00, and there is documentary evidence that many are poorer and worse off than before. One cannot help but wonder if the families intended as beneficiaries of these schemes would

have been better off in most instances if the World Bank had simply given them these thousands of dollars, which could have been used to purchase the good agricultural land they had no access to,or to set up small business enterprises. At the same time, the tremendous ecological destruction that results from such projects would have not have occurred.

IV. Two Recent Projects of the World Bank and IDB

A. The World Bank's Brazil Northwest Development Program (Polonoroeste): An Ecological Debacle

In spite of these extraordinary risks and costs for colonization projects in humid tropical tropical areas in Latin America, the World Bank approved nearly a half billion dollars of loans over the past three years for the Brazil Polonoroeste program, which exemplifies all of the uncertainties and failures of previous Amazonian colonization schemes.

Polonoroeste involves the paving of a 1500 kilometer highway through the heart of southwestern basin, construction of feeder and access roads, and construction of 39 rural settlement centers to consolidate and attract tens of thousands of settlers in area of Amazon forest the size of Great Britain or West Germany. The Polonoroeste Program area encompasses the entire Brazilian state of Rondonia and a part of Mato Grosso. Between five and nine thousand Amerinidians belonging to about 25 tribal groups are thought to live in the area.

The Bank's involvement in Polonoroeste has been a subject of great controversy from the beginning (1979), since the soils in Polonoroeste are typically highly variable, ranging from mediocre to poor. Partly in response to international controversy and pressure, the World Bank provided for setting aside two Biological Reserves, a National Park, four Ecological Stations (which would also be protected natural areas), and national forest areas. The Bank conditioned its participation in the program on adequate demarcation and protection of over 15 Indian Reserves, and implementation of health measures to protect the Indians. Most importantly, one of the loan agreements between the Bank and the Brazilian government contained specific provisions in which the Brazilian government pledged that Polonoroeste settlements would not occur on unsuitable soils or soils of unknown quality, or menace the numerous areas to be protected.

The Bank justified its role as primarily one of consolidating and stabilizing existing settlements in an area

already open for colonization and of ensuring protection of the environment and of the thousands of indigenous people inhabiting Rondonia. Yet $240 million, or 54% of the Program loans went for paving the 1500 kilometer highway leading to the region, which, given the promotion of colonization by the Brazilian government, many predicted would lead to the accelerated migration and deforestation that is now occurring. (Fearnside, Philip M., "Deforestation in the Brazilian Amazon: How Fast is it Occurring," Interciencia, Vol. 7, No. 2, 1982)

What is now occuring in the Polonoroeste region is an ecological, human and economic disaster of tremendous dimensions. Almost none of the environmental and Amerindian components have been implemented, and the rate of deforestation in the Polonoroeste Program area is the highest in the Brazilian Amazon, and increasing explosively. Rather than being 'consolidated,' as was the intention of the Bank, settlers are abandoning their cleared land since it cannot support perennial agriculture; in many instances they are selling it to larger landowners for cattle ranching, a use which numerous past experiences in the Amazon have shown will also be unsustainable. Intended protected natural areas and Indian reserves have been invaded by spontaneous settlement, now out of control, and in one such area, the Lourdes Indian Reserve, the threatened tribe recently took a dozen settlers hostage in a desperate attempt to force the government to protect its lands.

In one part of Polonoroeste--the Guapore Valley-- the Brazilian government is constructing a highway (Br-429, linking the towns of Presidente Medici and Costa Marques) as part of a settlement scheme for 8000 families in the area. This highway and associated settlement directly menace adjacent areas which were intended to be reserves: the Pacaas Novas National Park, the Guapore Biological Reserve, and the Ur-Eu-Wau-Wau and Rio Branco Indian Reserves. This is a flagrant violation of one of major loan stipulations between the Bank and the Brazilian government; in addition, soil maps prepared by EMBRAPA (the Brazilian agricultural research agency) in 1983 show that most of these new settlement areas in the Guapore Valley have soils inappropriate for small farmer agriculture--another direct violation of the loan agreement, which states that

> the Borrower shall take all necessary measures: (a) to discourage the agricultural exploitation of areas which have been determined to be unsuitable for agricultural development or of areas whose suitability for agricultural development has not been determined; and (b) to prevent the occupation of areas that have been legally defined as reserves. Loan Agreement, World Bank Loan No. 2060 BR.

According to the Treasury Department, as of July 31 the Bank had disbursed $178.3 million of the total of $443.4 million approved for the Polonoroeste Program in six loans. Most of this money has been for the road construction and paving--$136.2 million. Given the large undisbursed amount, the Bank still has considerable leverage and should take immediate actions, including threatening to halt all further loan disbursements, to enforce its own loan conditions and mitigate the ongoing devastation of the Polonoroeste Region. Of special gravity is the ongoing settlement of the Guapore Valley and construction of Br 429, which the Bank must demand a halt to immediately if it is not to make a mockery of the conditions of its own loan agreements.

Most importantly, the World Bank (and IDB) must take measures to ensure that they do not become involved in the future in ecological disasters of this kind.

B. The IDB's Pichis Valley Project

The IDB also continues to finance colonization schemes in tropical forest areas with poor soils and little or no sustainable agricultural potential. In 1982, the IDB approved loans totalling $46 million for a jungle roadbuilding and agricultural settlement project in the Pichis Valley in the Peruvian Amazon. The Bank did incorporate environmental mitigation measures in its project design, but this type of emvironmental planning is analogous to sending a Doctor to mitigate the health impacts of a purposely planned automobile accident.

In fact, the Peruvian government initially approached the World Bank for funding in the Pichis Valley, and it refused, for which it should be praised. A World Bank/FAO team visited the Pichis Valley and adjacent jungle areas in the Spring of 1981 and assessed the agricultural potential of the region as folows:

> *97% of the area is at present under forest....
>
> *The soils are mostly highly acid...and are low in nutrients...there is a high proportion of sloping land....
>
> *Under the climatic and topographical conditions of the project area, [highway] maintenance costs are likely to be high....

*A forestry project in the area [would be] financially marginal...

*Soils are of low fertility...and consequently limit the forest's natural regeneration capacity....

*An increased flow of spontaneous settlers would aggravate the conflict over land tenure with native communities and would have a disaserous effect on the area's ecosystem.....

*The mission debriefed with the Government of Peru and warned of the low potential of the area proposed for development."

In spite of this highly negative assessment by FAO and the World Bank of the development prospects for the Pichis Valley, the IDB has cited its involvement there as a model and predecent in environmentally sound development. Of the total project costs, however, 65.3% will go for jungle road construction, 14.9% for forestry and agricultural management and development, and only 0.3% for an "Environmental Dimension Program."

V. Inadequate Environmental Research, Guidelines and Staffing of the MDBs for Agricultural Projects in Latin America

Given the severe environmental impacts of MDB agricultural projects in Latin America, especially with respect to tropical deforestation, hope for improvement would seem to lie at least partially with research that would explore evironmentally more sustainable types of agricultural development, and with the incorporation of stringent environmental guidelines and procedures in the design of projects. The performance of the World Bank and IDB in supporting and implementing environmental research and guidelines for agriculture is for the most part abysmal.

The World Bank undertakes an extensive program of research, amounting in 1983 to over $25 million, or 4.56% of its entire administrative budget. Over the past twelve years over 160 centrally approved research projects have been completed, and over 150 are currently in progress, in addition to some 65 smaller research projects being conducted by research units in other bank departments.

It is deeply disturbing, then, that a perusal of "Abstracts of Current Studies" of the Bank's Research Program for

1983--which gives brief descriptions of 122 research projects in progress during that year--does not list a single project which relates even remotely to sustainable management of natural resources or environmental planning. Twenty-two ongoing research projects are described for the sector of "Agriculture and Rural Development;" as with the research in other sectors, the projects focus exclusively on micro-and macroeconomic concerns such as agricultural pricing policies.

Given this complete absence of the natural resource and environmental sector in the Bank's research program, it is all the more disturbing to read the Bank's statement on the role of its research:

> The World Bank's research program is intended to contribute to a deeper insight into the development process and the policies affecting it, to introduce new techniques or methodologies into the Bank's operational and analytical work at country, sectoral, and project levels, and to help strengthen indigenous research capacity in developing member countries....To the extent possible, collaborators from client countries are also actively involved in the research process. The wide-ranging topical interest of the research portfolio is a reflection of the...data needs of the Bank as a leading development institution.("Abstracts of Current Studies 1983," The World Bank, 1983, p. 3)

The World Bank also is involved in research through its contributions ($19 million in 1983) to the thirteen institutions in the Consultative Group on International Agricultural Research (CGIAR), for which it serves as the Secretariat, and in components attached to projects. Although it is not possible here to discuss at length the environmental implications of CGIAR research, it should be noted that for the most part it is exclusively, some would say dangerously, focused on increasing production without adequately taking into account long term concerns of environmental suitability and ecological sustainability.

The other way in which the World Bank supports agricultural research is through components in individual projects; its funding of environmental research related to agriculture has been almost insignificant. One praiseworthy aspect of the otherwise largely disasterous Polonoroeste Program was World Bank support for a small ecological research component. The IDB Pichis River Project also has an ecological research component, also tiny in comparison with the project's total budget. Ironically, when MDB agriculture and rural development projects pose enormous environmental risks and threats, then ecological research receives some attention--whereas the goal of such research should

be to channel development away from such clearly unsustainable projects in the first place.

The IDB does not have a central research program comparable to the World Bank's, but it does contribute substantially to the support of the three CGIAR instutions in Latin America ($9.1 million in 1983) and supports agricultural research through individual projects, or components of projects. Not surprisingly, this research support has had an emphasis similar to other IDB agricultural lending, with livestock research being a signicant part. Like the World Bank, the IDB has given virtually no support for research which would explore or promote ecologically more sustainable agricultural projects.

Both Banks also lack adequate environmental guidelines and procedures which could improve the design of agricultural projects. In May of this year the World Bank issued a new statement on environmental policy and procedures, for which it deserves praise, since it was incorporated in the Bank's Operations Manual, making it, theoretically, at least, mandatory for Bank staff.

The Bank's May, 1984 environmental policy document states that "the Bank periodically publishes environmental guidelines distilled from a wide range of national and international recommendations and standards. These guidelines suggest acceptable ranges to be followed in Bank operations unless the borrowing country's standards are stricter." ("Environmental Policies and Procedures of the World Bank," The World Bank, May 1, 1984, p. 3.) The guidelines to which the policy document refers are indeed voluminous, numbering hundreds and hundreds of pages in two volumes; one of the outstanding characteristics of the guidelines is that there are almost none for the Bank's single most important lending sector: agriculture. The single agriculture related activity for which any kind of guidelines have been produced is pesticide use, and even these are seriously inadequate in some respects and do not even refer to the existence of technologies such as integrated pest management (IPM).

The IDB has prepared for various sectors a series of 'environmental checklists' for which no procedures or requirements exist to ensure that they are integrated, used, or even looked at by Bank staff in designing and appraising projects. In 1979, the IDB adopted an Environmental Management Policy, but the lack of any procedures to ensure environmental review of agricultural and other kinds of projects make this

general policy commitment virtually meaningless.

Procedures and guidelines aside, both Banks suffer from a critical lack of staff professionally qualified to evaluate the environmental and ecological consequences of agricultural devlopment projects. The World Bank has only one professional ecologist among its nearly 6000 employees, and only one individual in its staff is currently involved in reviewing the prospective environmental impacts of proposed agricultural projects in even a sporadic way. The IDB suffers from a similar lack of personnel trained in ecology and, unlike the World Bank, does not even have an identifiable locus of environmental review or policy operations.

VI. Alternatives to Current MDB Agricultural Projects

There exist promising directions of agricultural use and research in both Central America and the Amazon which could provide alternatives to the agricultural systems and projects which have caused so much devastation in the past. In fact, some of these agricultural practices were first explored in pre-Colombian times by native groups which obtained nearly all of their resources through sustainable management of the humid forest biome. Often, too, these practices have survived up to the present day among Indian people who occupy the jungle; occasionally, they have been rediscovered and have become the subject of systematic research to determine how they might be intensified or utilized elsewhere. Research and pilot projects for these alternatives are being supported on modest scale by local government research institutions, and some international agecies and non-governmental organizations. The two overwhelmingly most important develoment institutions operating in Latin America--the World Bank and IDB--are conspicuous through their lack of attention to these alternatives.

I will briefly review some examples, though I wish to submit for the hearing record, with the permision of the Chairman, two articles that describe them in more detail: "Central America's Tropical Forests: Positive Steps for Survival," James D. Nations and Daniel I. Komer, Ambio, Vol. 12, No. 5, pp. 232-238; and "Conservation, Kuna-Style," Mac Chapin and Patrick Breslin, Grassroots Development, Vol. 8, No. 2, pp. 26-35.

A. Management and Conservation of Tropical Forest Areas by Indigenous Peoples

In many parts of the Third World, indigenous people have the

most sophisticated and complete knowledge of the characteristics of the ecosystems they inhabit, especially unstudied tropical forest areas. Making efforts to involve them as active participants and planners in development and environmental protection activities should be made a priority for MDB projects which affect these peoples and the areas they inhabit. A model example of how this can be done is a program in Panama currently supported by U.S.A.I.D., the Inter-American Foundation, World Wildlife Fund and the Smithsonian Tropical Research Institute. The program involves the establishment and management of a forest park and reserve by the Kuna Indian Tribe in an area unsuitable for sustained agriculture:

> To prevent the destruction of their rainforest teritory the San Blas Kuna have begun a series of projects designed to utilize the forest as forest, thus demonstrating "use" of the land to ousiders while simultaneously creating jobs, producing income, and protecting both rainforest and Kuna cultural identity. The projects include a forest resource inventory, an agroforestry station, a botanical park...and a program of scientific tourism that will allow photographers and researchers to study and enjoy one of Central America's most pristine rainforest areas. Nations and Komer, op. cit., p. 234.

B. Agricultural Exploitation Based on Traditional and Indigenous Use of Local Fauna and Flora

Numerous groups of local and indigenous people have evolved and continue to use sustainable agricultural practices in humid tropical forests. In the Amazon, for example, the older settlers (i.e., those who preceded the government induced colonization of the past 20 years) live from the forest in a sustainable fashion as rubber tappers, brazil nut gatherers, "caboclos" (jungle farmers), and from sustainable harvesting of the forest's incomparable wildlife and fish resources.

The fish resources of Amazonia are a particularly neglected development resource. (cf. Robert J. A. Goodland and H. S. Irwin, Amazon Jungle: Green Hell to Red Desert?, 1975, Chapter 3.) The Amazon region has the earth's richest fish fauna, with more than 2000 species, twice as many as in the Atlantic Ocean. Investment in research and development of fish culture in the Amazon would be environmentally sound and could be one of the "brightest economic possibilities of the whole area." (Goodland and Irwin, op. cit.

Both in the Amazon and in Central America forest and

riparian fauna could be farmed on a sustainable basis both for local consumption and for export. "Alligators, turtles, capybara, tapir, paca, manatee and dolphin all command high prices and could be raised from nutrients mainly of fluvial origin....Turtles...formerly referred to as the 'cattle' of the Amazon,' were raised in abundance by Amerindians." (Goodland and Irwin, op. cit., p. 44.) Mexican researchers have turned their attention in recent years to indigenous forms of wildlife management and to the possibility of exploiting underutilized tropical forest wildlife resources. For example, a significant part of the biomass of some forests in Central America is constituted by the Agouti paca, a small rodent like mammel. Researchers at Mexico's national Institute of Ecology have concluded that the paca could be domesticated and managed by settlers in tropical forest regions to provide both food and revenue. (cf. P. Reyes Castillo, ed., Estudios Ecologicos en el Tropico Mexicano: Selva Lacandona et Laguna Verde, Mexico: Instituto de Ecologia, 1981.)

In particular, indigenous peoples living in tropical forest areas have evolved in many instances highly sophsticated agricultural systems based on an intimate knowledge of local ecological conditions. Regrettably, develoment institutions such as the World Bank and IDB are doing little to investigate, preserve and utilize this knowledge and much, through ill conceived agricultural projects, to accelerate its destruction and loss for all time. In the words of one anthropologist

> "with the extinction of each indigenous group, the world loses millenia of accumulated knowledge about life in, and adoption to tropical ecosystems. This priceless information is forfeited with hardly a blink of the eye: the march of develoment cannot wait long enough to find out what it is destroying." Darrell A. Posey, "Indigenous Ecological Knowledge and Development of the Amazon," in Emilio F, Moran, The Dilemma of Amazonian Development, pp. 225-257.

C. Labor-Intense Indigenous Agrosystems

Two systems dating to pre-Colombian times which have received considerable attention from both Mexican and American researchers are tropical chinampas and Lacandon agro-forestry. Similar systems have been evolved by indigenous peoples in other parts of tropical Latin America, and many have unstudied and unrealized practical possibilities for developing sustainable models of agricultural exploitation in humid tropical forest areas.

The most impressive feature of ancient Maya farming

strategies may have been their extensive use of chinampas, whose traces have been found throughout Mesoamerica. Chinpampas are a form of self-sustaining, labor intensive agriculture in which small plots of land are built up and separated by irrigated channels. The soil in these plots is continually built up with organic material and mud from the channels, which abound in nitrogen fixing plants and aquatic small animals. According to the conclusions of a 1980 U.S.-Mexican Seminar on Land Use Strategies in Middle American Cultures and Their Use in the Modern World, this system "reaches levels of production and ecological efficiency difficult to surpass using any modern agricltural system." (Biotica, Vol. 5, No. 2.)

Research and pilot projects conducted in Mexico have investigated how this system might be modified and reintroduced on a large scale into humid tropical areas. These projects have been successful, and a system of chinampas and agro-forestry has been proposed by Mexican scientists as an alternative to current patterns of land use in many tropical forest areas. [cf. Elizabeth Maier, La Chinampa Tropical. Una Primera Evaluacion, Mexico, CECODES, 1979; Arturo Gomez Pompa, "An Old Answer to the Future," Mazingira, No. 5, 1978, pp. 50-55]

According to several researchers, the Lacandon Indians in southern Mexico have preserved many of the ecological skills of their Maya ancesters and have developed a system of agro-forestry which may well provide a model for sustained development throughout the region. Characteristically, Lacandon farmers plant only 0.75 ha. of land, but they pack these small parcels so densely with cultigens that little weeding or other effort must be devoted to them after the initial tasks of clearing forest growth are completed. From this "cultivated jungle," they harvest up to 40 different kinds of plants, including several different types of beans, squash, condiments and greens, and medicinal herbs. Cultivated areas are deliberately 'over-planted' with certain types of squash which attract deer and other wildlife which can be hunted.

Lacandon corn yields average five tons per hectare, whereas the corn plots milpas of jungle colonists rarely exceed two tons per hectare. Moreover, the extensive milpas of the colonists have to be abandoned after two or three seasons, the fallow Lacandon plots (known as acahuales permit native hunters to enjoy a regular harvest of animal protein with minimal expenditure of energy.

D. Other Agroecosystems

There are a number of other indigenous, intensive agroecosystems which could serve as the basis for more

ecologically sound, alternative agricultural development in both Central America and the Amazon. These include home and orchard gardens, ridged fields and jungle terraces. (Nations and Komer, op.cit.; Goodland and Irwin, op. cit.) In fact,

> ...some of the most promising of these agroecosystems are emerging from archaeological research on the economic bases of previous tropical American civilizations. Both archaeologists and agronomists are intriqued by the fact that groups like the Maya sustained huge populations in areas that, today, are being devastated by modern agricultural practices. Nations and Komer, op. cit., p.236.

VII. Recommendations and Conclusion

The six national environmental organizations I represent today are gravely concerned by the World Bank's and IDB's continued planning and financing of agricultural development projects in Latin America which are contributing to the destruction of that region's natural resource base, particularly humid tropical forests. These groups respectfully urge the Subcommittee to complement and complete the extremely valuable information gathering and oversight process it has initiated with this hearing by taking the following measures:

A. Requesting the Treasury Department to obtain accounts from the World Bank and IDB concerning the following: 1) their research activities, current and planned, concerning the ecological impacts and aspects of agricultural develoment projects, particularly livestock and land settlement projects; 2),their research activities and support, current and planned, relating to alternative agricultural models and systems such as the ones discussed in this testimony and in the testimony of other witneses.

B. Requesting the Treasury Department to obtain an account from the World Bank of what measures it currently plans to undertake to 1), deal with the numerous environmental and Amerindian rights problems currently plaguing the Polonoroeste Program; 2), what measures it plans to undertake to ensure it will not be involved in ecological disasters such as Polonoroeste in the future.

C. Sending through the Treasury Department to the World Bank and IDB for comment the testimony of witnesses today who discussed the agricultural research, projects or policies of these institutions.

D. Scheduling hearings next year on the ecological and environmental aspects of agricultural development projects conducted by the MDBs and other international institutions in Africa and Asia.

Mr. Chairman and members of the Subcommittee, the organizations I represent wish to express their great appreciation for your holding this hearing, which delved into issues of tremendous importance for all who are concerned with the prospects for sustainable economic development and conservation of threatened natural resources and tropical forests in Latin America.

Thank you very much.

Central America's Tropical Rainforests: Positive Steps for Survival

BY JAMES D NATIONS AND DANIEL I KOMER

Before the Europeans "discovered" and colonized Central America, the region probably had around 400 000 km² of lowland and lower montane tropical rainforests. Today, more than two-thirds of Central America's rainforests have been eradicated and the remaining forested areas are disappearing at the alarming rate of 4000 km² a year. Despite this grim record, the prognosis is not all black. A number of projects, both small- and large-scale, are underway that involve the local populations and utilize the rainforests in a sensible and sustainable manner.

When the 16th Century Spanish *conquistadores* touched shore on the territory that would later be called Central America, the region was covered by around 400 000 km² of lowland and lower montane tropical rainforests (1). Stretching from the eastern shore of central Mexico to the Darién rainforest of southern Panama, these rainforests teemed with tropical plants and exotic wildlife. Indigenous peoples searched the forests for food and raw materials, burned huge areas to create savannahs crowded with wild food animals, and practiced highly productive, intensive agriculture. Then, with the arrival of Western civilization, Central America's rainforests began to change.

Today, almost five centuries later, more than two-thirds of the region's original rainforests have been eradicated in the name of survival, progress, and profits. Numerous species of animals and plants are threatened with extinction. If current patterns of clearing and burning are not drastically altered, much of the final third of the region's rainforests will be eradicated during the next 20 years, leaving only a few degraded forest relics in national parks and reserves (2). The region's rainforest inhabitants face an equally grim future. Most use obsolete agricultural techniques to raise Old World crops such as rice, coffee, bananas, and cattle. Many suffer from landlessness and poverty, and some from malnutrition (see Figure 1).

Despite this harsh assessment, the future of Central America's tropical rainforests and the future of the people who live in them hold forth some strong signs of hope. The region's leaders are fast becoming aware of the folly of wasting their remaining rainforests to produce quick profits or to postpone confrontation with population growth and the need for land reform. Now, increasingly, Central America's citizens are realizing that by halting rainforest destruction they can benefit both their own nation's people and the general health of the planet.

On at least three different levels—local, national, and international—organizations and individuals are struggling to promote

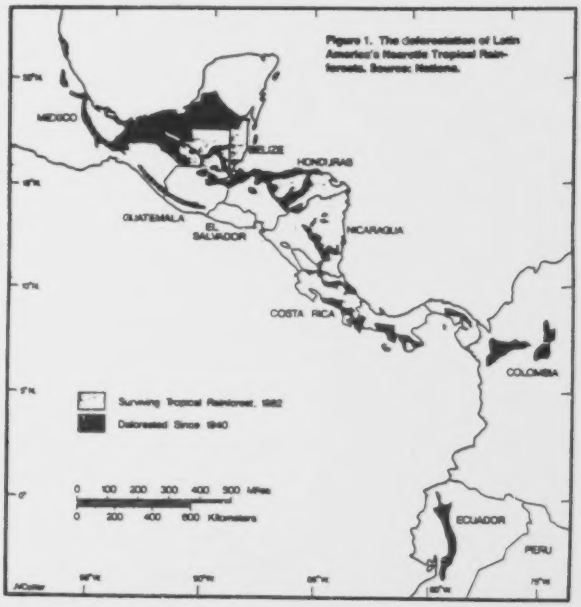


Figure 1. The deforestation of Latin America's Humid Tropical Rainforests. Source: Nations.

Table 1. Lowland and lower montane tropical rainforests in Central America (Mid-1980).

Country	Undegraded rainforest	Current rate of loss per year	Major threats
Nicaragua	27 000 km²	1 000 km²	cattle ranching
Guatemala	25 700	600	colonization, cattle ranching
Panama	21 500	500	cattle ranching, logging
Honduras	19 300	700	cattle ranching, colonization
Costa Rica	15 400	600	cattle ranching
Belize	9 750	32	colonization
Mexico	7 400	600	cattle ranching, colonization
El Salvador	0	0	(deforested)
TOTALS	128 050 km²	4 032 km²	

A few kilometers south of Kuna Indian territory in Panama, a bulldozer carves a swath through virgin rainforest for a road. By finding ways to utilize the rainforest as forest, the Kuna Indians hope to prevent similar destruction in their own region. Photo: J Nations.

the wise use and conservation of Central America's remaining tropical rainforests. Their success in this struggle will help determine the living conditions of Central Americans today and those yet to come. More than this, the struggle will also affect the rest of the world's citizens, including those who will never see the shores of Central America.

HISTORY OF RAINFOREST EXPLOITATION

During the first 400 years after European contact, most of the rainforests of Mexico, Central America, and Panama remained intact. In fact, in a few specific areas, the amount of forest actually increased during the first centuries of colonization. Diseases, warfare, and slavery decimated the region's indigenous populations, and areas they had cleared for crops or for harvesting wild game reverted to forest (3).

During the 20th century, however, the commercial success of crops such as coffee, bananas, oil palm, and cattle have led the descendants of both invaders and Indians to convert huge tracts of rainforest into cropland and pasture. This conversion is fueled by population growth, inequitable land distribution, and international markets for export products, especially beef cattle.

The current trends in Central America's rainforest regions are toward the increasing transformation of forest and cropland into pasture for beef cattle, a decline in the number of people rainforest lands can support, increasing dependence upon the vagaries of external markets, and the impoverishment of plant and animal life and most of the region's people. Admittedly, a few individuals are temporarily benefiting from the process of deforestation, especially loggers and cattlemen, and the developed world consumers who enjoy the short-lived fruits of rainforest destruction. But all of these benefits are produced at great social and environmental cost to Central America and its citizens.

POSITIVE STEPS

In the face of this ongoing deforestation, some Central Americans are finding positive ways to use and protect the region's rainforests. Their action takes a variety of forms, ranging from the local activities of indigenous groups to coordinated national

tional development and conservation organizations.

Indigenous Conservation

One of the most engaging success stories is that of the Kuna Indians of the Comarca of San Blas, Panama. On the northeastern shore of that nation, some 28 000 Kuna are struggling to protect a thin strip of 3106 km² of tropical rainforest that stretches —east to west—from Colombia almost to the Panama Canal. The San Blas Kuna still control large tracts of uncut forest land because they are primarily fishermen and coconut farmers who live on small islands just off the coast of their mainland territory. As anthropologist Mac Chapin has pointed out, they also have a cultural tradition of viewing the rainforest as the "domain of potentially malevolent spirits which are prone to rise up in anger and attack entire communities if their homes are disturbed" (4).

Although the rainforest of the Comarca of San Blas was legally ceded to the Kuna in 1930, recent illegal encroachment by cattle ranchers and colonists threatens to destroy both the forest and the Kunas' rightful claim to it. Behind this threat is the attitude that rainforest areas which are not being "used" may be expropriated by those willing to "improve" it by clearing the land and dedicating it to agricultural production or cattle ranching (5). Immigrant colonists have begun to slip across the Comarca's long, unprotected border to burn the forest and sell the "improved land" at US $80 per hectare to cattle producers and week-end ranchers from Panama City. This same process is eradicating the rainforest of the Bayano and Darién regions of southeastern Panama at the rate of more than 500 km² per year (6) (see Box 1).

To prevent this destruction of their rainforest territory, the San Blas Kuna have begun a series of projects designed to utilize the forest *as forest*, thus demonstrating "use" of the land to outsiders while simultaneously creating jobs, producing income, and protecting both rainforest and Kuna cultural indentity. The projects include a forest resource inventory, an agroforestry station, a training program for Kuna park guards, a botanical park with trees labeled in Kuna, Spanish, and Latin, and a program of scientific tourism that will allow photographers and researchers to study and enjoy one of Central America's most pristine rainforest areas (7).

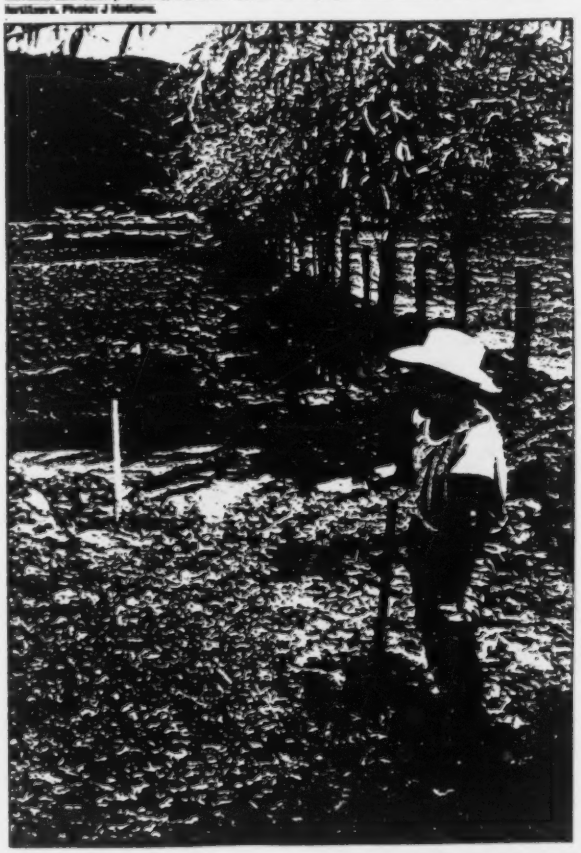
The Kunas' program is now receiving crucial financial and technical assistance from Panamanian and international organizations, but the ideas, the work, and much of the money spent so far have come from the Kunas themselves (8). In this sense, their efforts constitute one of the most successful examples of indigenous protection of tropical rainforest in Latin America. Their example also reinforces an idea that is becoming a guiding principle in natural resource protection: wherever local people are involved *from the beginning* in planning and carrying out programs of natural resource conservation, both the resources and people prosper (9).

A second example of positive action in the protection of Central America's tropical rainforests is also the outgrowth of indigenous activities. Scientists throughout the region are investigating traditional Indian farming systems that could be adapted for use by immigrant farm families who would otherwise practice slash-and-burn agriculture or cattle ranching. By combining the ecologically sound, sustained-yield principles of traditional Indian agriculture with specific techniques of commercial agriculture, researchers are creating new production systems that can help rainforest colonists and conserve forest resources at the same time. This is possible because these intensive systems allow farmers to maintain production of food and cash crops on land that has already been cleared, thus relieving pressures to constantly expand into additional forest land.

Tropical Chinampas

Mexican researchers are experimenting with the centuries-old food production technique of tropical *chinampas* (10). This system can be utilized anywhere that water

Near the highland town of San Cristóbal las Casas, Chiapas, Mexico, a Chamula Indian completes a chinampa farming system he is creating in a rented boggy pasture. By piling the excavated soil onto the elevated cultivation platforms, the farmer can harvest crops year round without the use of chemical fertilizers. Photo: J Mathieu.



A Lacandon Maya farmer stands at the edge of an agricultural plot dominated by tobacco, bananas, maize (corn) and sweet potatoes in the rainforest of Chiapas, Mexico. The Lacandon Maya practice a highly efficient form of traditional agroforestry that allows them to cultivate small plots of cleared rainforest for up to 7 consecutive years. Photo: J Nations.

is available year round—a condition that is rarely a problem in rainforest regions. To create a *chinampa* system, the farmer digs narrow irrigation/drainage canals on three or more sides of a cultivation plot, then adds the excavated soil to the plot to raise it above the water table. The farmer maintains crop productivity by periodically dredging mud from the canals and adding it to the cultivation plots as organic fertilizer. Aquatic vegetation from the canals serves as "green manure," and fish that colonize the canals provide additional, high quality protein.

As their name implies, the irrigation/drainage canals allow the farmer to control his crops' water supply. By using the canals to irrigate plants during the dry season and to drain off excess water during the rainy season, the farmer can maintain year-round production of cash crops, food crops, and trees in a system that is both ecologically and economically sound.

Experiments conducted by Mexico's Instituto de Investigaciones sobre Recursos Bióticos (INIREB) in Veracruz, and the Colegio Superior de Agricultura Tropical in Tabasco, have demonstrated that tropical *chinampas* can produce constant and abundant harvests in areas previously considered useful only for pasture or wet-crop cultivation. INIREB's experimental *chinampas* produced food and cash crops for a family of five on only 2000 m^2 of land.

Additional benefits of the *chinampa* system come from the fact that the farmer plants trees along the canals to hold the soil in place. By selecting the proper tree species, the farmer can produce additional food, fiber, and fuelwood and create wind barriers and habitat for wildlife such as insect-eating birds. Moreover, the *chinampa* system does not require machinery, insecticides, or artificial fertilizers. The system is also compatible with cattle production, since crop residues and weeds can be used as fodder. In turn, the cattle provide meat and milk, and their wastes are added to cultivation plots as organic fertilizer (11).

Agroforestry

Central American researchers are also placing deserved emphasis on agroforestry, the generic term for systems that produce trees, crops, and animals on the same units of land. The basic tenet of agroforestry—planting trees *with* crops, rather than cutting down trees to replace them with crops—enables farmers to increase both their food supply and income without continually clearing new rainforest land (12).

In seeking the appropriate agroforestry systems for specific areas of Mexico and Central America, researchers are investigating the traditional agroforestry techniques of the region's indigenous peoples. One promising, though quickly disappearing, system is that of the Lacandon Maya, a rainforest Indian group in Chiapas, Mexico. The Lacandones practice a multi-layered cropping system that combines up to 75 crop species on single hectare plots. After five to seven consecutive years of harvests in the same rainforest clearings, Lacandon farmers plant the plots with tree crops such as rubber, cacao, citrus, and avocado. Far from being abandoned fields, these "planted tree gardens," as the Lacandones call them, continue to provide food and raw materials as the clearings regenerate with natural forest species. When forest regrowth finally overcomes the fruit tree crops, the farmers clear the plots for a second cycle of food and forest (13).

In such a fashion, a traditional Lacandon farmer clears fewer than 10 hectares of rainforest during his entire agricultural

ists in other rainforest areas, such systems of sustained-yield forest farming could dramatically improve the quality of life for rural families and prevent the destruction of renewable forest resources.

Other Agroecosystems

Other researchers are focusing on ecologically-sound, intensive production systems such as "orchard gardens," hillside terraces, and ridged fields (15). Interestingly, some of the most promising of these agroecosystems are emerging from archaeological research on the ecosomic ilizations. Both archaeologists and agronomists are intrigued by the fact that groups like the ancient Maya sustained huge populations in areas that, today, are being devastated by the agricultural practices of the modern world (16).

Rainforest Parks and Reserves

Scientists as well as the general population in Central America also recognize the importance of preserving tropical rainforests in their natural state. In addition to providing lumber, raw materials, and new food and drug plants, Central America's rain-

A farmer's coffee crop is shaded by fuelwood and lumber trees in an experimental agroforestry plot near Turrialba, Costa Rica. Researchers with the Centro Agronómico Tropical de Investigación Enseñanza (CATIE) cooperate with local farmers to create viable systems of agroforestry that increase the farmers' production and protect their land from erosion. Photo: J Nations.

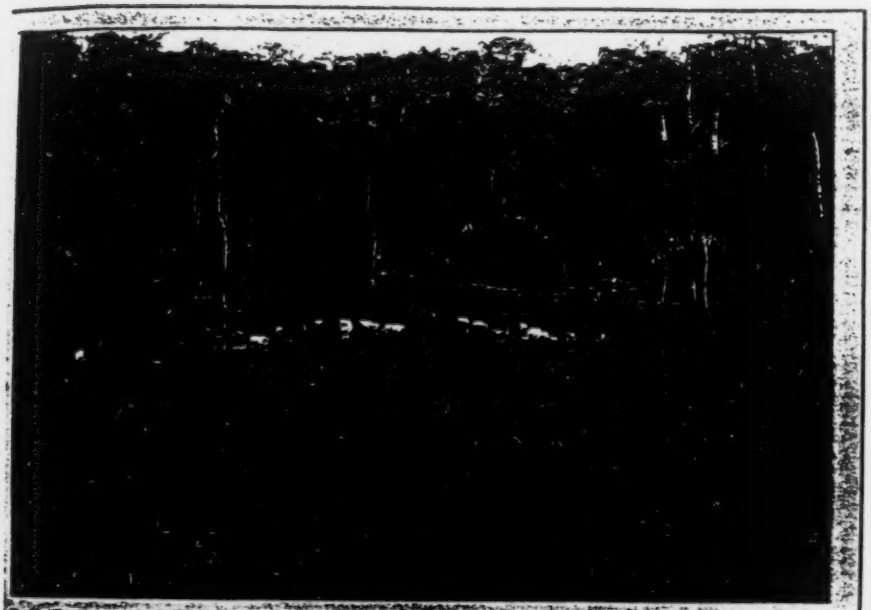
Box 1.

Cattle Production and Rainforests

Clearing and burning rainforest to produce beef cattle has been the number one cause of forest destruction in Mexico, Central America, and Panama during the past three decades. The fact that this destruction frequently is preceded by other forms of forest exploitation—namely, logging and peasant colonization—has led some researchers to dismiss the destructive aspects of cattle ranching in Central American rainforests. But, in reality, beef cattle production serves as the motive force behind a three-stage pattern of rainforest eradication.

The process begins when logging companies or oil companies bulldoze roads through the rainforest to extract commercial resources. Later, landless peasant families use these roads to filter into the forest in search of land. They clear the remaining vegetation to plant subsistence crops such as maize, manioc, and rice, and low-level cash crops such as coffee, chilies, and bananas. After one to three years of this production, however, insect plagues, weeds, and soil exhaustion lead the colonists to clear additional forest land for crop production. But rather than allow their previous crop land to regenerate into forest, they seed the area with introduced pasture grasses and begin to produce beef cattle (1). Or in an increasingly common pattern, they sell their cleared forest land to cattle producers who follow in their wake, buying up small plots to convert them into large ranches (2).

In many regions of Central America government agencies, multilateral development banks, and international development organizations have actively promoted the transformation of rainforest into cattle pasture by providing incentives such as generous loans, new roads and beef packing plants, and pest eradication programs. In most cases, these incentives appear to be designed to increase export earnings by expanding the amount of beef sold to overseas markets, especially western Europe and the United States. In response to this financial and technical support, exports of deboned, frozen beef were the most dynamic sector in Central American trade during the 1960s and 1970s, with a 400 percent increase between 1961 and 1974 alone (3). For the importing countries, Central American beef ends up in luncheon meats, hamburgers, frankfurters, chili, soups, beef stew, hash, sausages, TV dinners, frozen pot pies, baby foods, and pet foods, although—especially in the United States—some of it is mixed with fatter, domestic beef to appear on



sheds, preventing flooding, and controlling erosion and downstream siltation. For these and other reasons, the Central American nations are protecting specific areas of rainforest in national parks and forest reserves.

Both national and international organizations emphasize the importance of involving local people in the selection and protection of these rainforest reserves. For example, the government of Honduras recently created the 2500 km^2 Rio Plátano Biosphere Reserve in the La Mosquitia rainforest (see AMBIO No. 3–4, 1983). The area joins the expanding number of these conservation units under the aegis of UNESCO's Man and Biosphere Program (MAB). The Rio Plátano Reserve will protect the forest's abundant wildlife—jaguars, margay cats, ocelots, tapirs, harpy eagles, and scarlet macaws—but it will also protect the territory and lifestyles of the approximately 2000 Paya and Miskito Indians and a small number of Spanish-speaking farmers who live within its boundaries. The World Wildlife Fund–US, which provided funds for basic protection and management of the reserve, has noted that, "The continuing involvement of local Indians in the management and planning phases has been a major factor in the success of the project" (17).

CONCLUSION

Similar conservation measures throughout Mexico and Central America provide the hope that undegraded tropical rainforests will still exist in the region at the turn of the century and that other rainforest areas will be supporting populations on a sustained yield basis. [illegible] the need for continued research and for additional financial and political support for the growing movement toward the wise use of Central America's natural resources. For, despite these positive steps, much remains to be done. The region's rainforests continue to fall at an alarming rate; every year that current patterns of destruction continue means the permanent eradication of an additional 4000 km^2 of rainforest.

The fact that alternatives to this destruction are finally coming into play should stimulate the scientific community to redouble its efforts. Success in these enterprises will bring a brighter future for both the people and resources of the region. Failure will bring the increasing impoverishment of Central America's rainforests, wildlife, and citizens.

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Daniel I Komer is a former international banker who holds graduate degrees in International Banking and Finance. His current emphasis is the wise use of natural resources in Latin America, especially economically viable alternatives to tropical rainforest conversion. He serves as economist with the Center for Human Ecology. Both individually and as co-authors, the authors have published related articles in *The Bulletin of the Atomic Scientists*, *Journal of Anthropological Research*, *Environment*, *AMBIO*, and *Cultural Survival Quarterly*. Their address: Center for Human Ecology, PO Box 5210, Austin, Texas 78763, USA.

In Panama's virgin rainforest, Kuna Indians are encountering a threat to their cultural—and material—survival: the steady advance of slash-and-burn agriculture. Encroaching settlers are turning jungle into desert. Patrick Breslin, a novelist, and Mac Chapin, an anthropologist, describe how the Kuna are adapting to this challenge by turning part of their reservation into a forest park and wildlife refuge that includes research facilities for scientists from around the world.

CONSERVATION KUNA-STYLE

PATRICK BRESLIN and MAC CHAPIN

When a Kuna Indian awakens on one of the small coral islands off the Panamanian coast where most of his people live, his gaze wanders past the thatched houses of his neighbors, out over the low-riding canoes of farmers headed for their mainland plots, and then across a mile or so of shimmering water to a mass of green forest rising, virgin and luxuriant, to the ridge of the San Blas mountains. At his back, the sun climbs above the calm Caribbean, and its first rays strike the tufts of mist snagged like fleece in the clefts of the hills. For generations, this dawn panorama, serene and unchanging, has greeted the Kuna people.

But if he were standing atop the 2,400-feet-high San Blas range, the view down the other slope would be less reassuring. Large swaths of thick vegetation have fallen victim to the machete and the torch. Ash-gray tree trunks stand above the denuded landscape, skeletal remnants of the once-towering jungle.

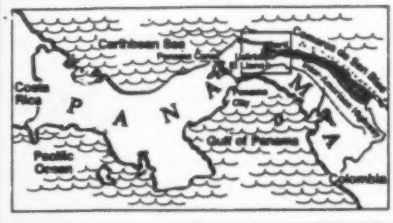
For several years now, peasants from the increasingly arid interior of Panama have been slashing and burning—implacable as soldier ants—toward Kuna land. Cattle drove many of them from their previous homes when ranches, producing beef for the international market, expanded onto farming land. And cattle are close behind them again. In three or four years, when the newly cleared and shocked land will no longer support subsistence crops of bananas, rice, corn, and manioc, farmers will plant pasture and try to sell their holdings to the ranchers. In a few more years, the ecologically fragile soils will be so leached that even cattle-ranching will fail. The tracks of this future already can be read on the San Blas' southern slopes and lower ridges, where the erosion that will inevitably claim all the cleared acres has already begun.

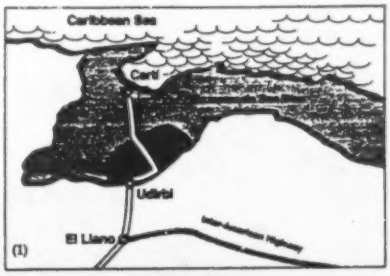
Panama's land-hungry peasants are involuntary recruits in the massive army of uprooted settlers that is on the march throughout the tropics. If unchecked, this process will complete the destruction of the world's tropical rain forests in our children's, if not our own, lifetimes. Some 900 million hectares of tropical moist forest remain; but it is disappearing, according to a 1981 United Nations satellite study, at a rate of 7.3 million hectares a year. Other, more pessimistic estimates put the annual loss as high as 20 million hectares.

If the tropical forests disappear, countless plant and animal species will vanish, many of them before man has had a chance to name, much less study them. About half the world's estimated 5 million to 10 million plant and animal species are found in tropical moist forests. Yet according to the U.S. government's recent report, *Global 2000*, as many as 1 million of those species could be extinct at the end of the century.

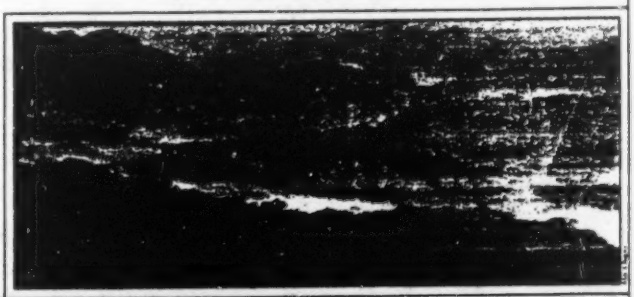
In many parts of the tropical world, the assault seems uncontainable: expanding populations, central governments driving forward with development schemes, the spread of agriculture and ranching for the export market, the resulting concentration of land ownership that forces peasants to strike out for the frontier, all pose threats to the forests. But in Panama, a well-organized native people, with support from the scientific community and a host of international agencies, may be able to save one of the last remaining virgin rain forests in Central America. The Kuna have decided to turn part of their reservation into a forest park and wildlife refuge with research facilities for scientists from around the globe. When the administrative and housing center opens to scientists in late-1984, Udirbi will be the first park of its type in the world created and run by an indigenous group.

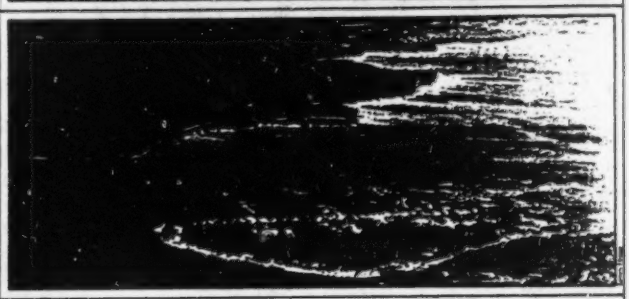
The Kuna are one of the few indigenous groups in all the Americas to survive the impact of the white man with their cultural and political autonomy intact. When the Spaniards made their appearance in the early 1500s, Kuna territory encompassed large tracts of the Darién jungle, spanning

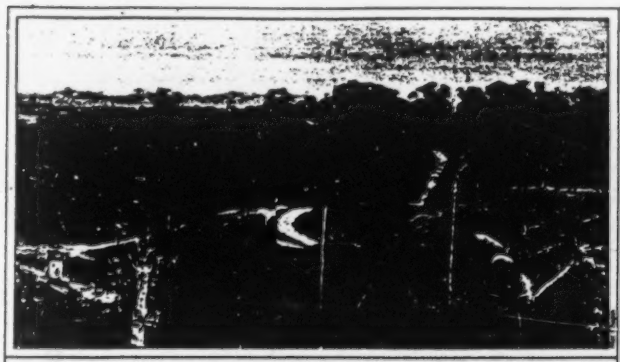




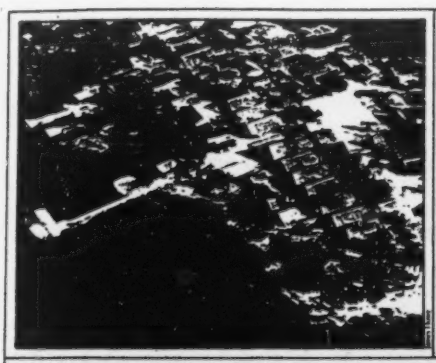
The Comarca of San Blas, the traditional homeland of the Kuna Indians, stretches more than 200 kilometers along Panama's Atlantic coast. The inset beside the accompanying map shows the location of the Udirbi Park (1). Mist-shrouded rainforest within the Udirbi Park (2). Aerial view of a Kuna island village, with the coastal plain in the distance. Virtually all farming occurs on the mainland, within a few kilometers of the shore (3). Kuna farmer standing amid his densely intercropped forest "farm." He carries freshly harvested manioc roots; his crops include coffee, cacao, bananas, pineapple, chile peppers, and fruit trees (4). Two Kuna girls wearing their everyday dress: *molá* blouses, strings of multi-colored beads, and wrap-around printed cloth skirts (5). Dancers with pan pipes and gourd rattles performing in an island community (6).

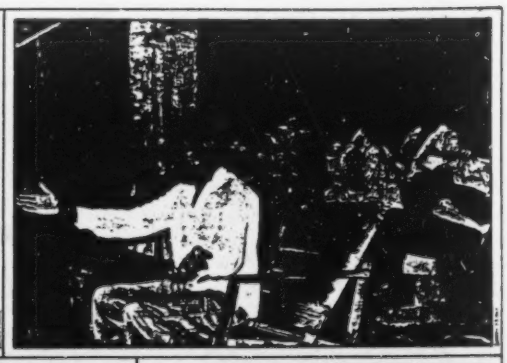




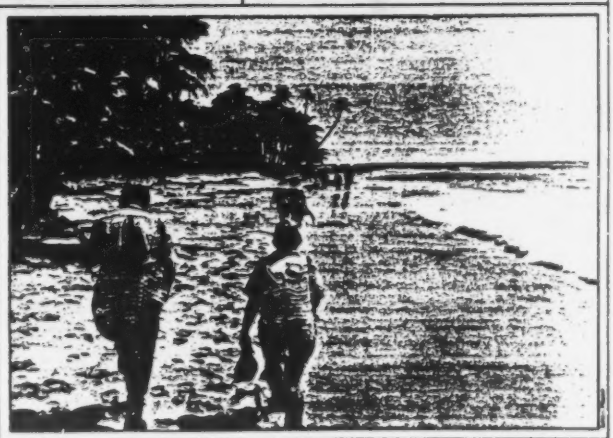


Much of the land on the southern slope of the Continental Divide is being deforested. The El Llano-Cartí road, which snakes through the hills toward the reservation, is a mixed blessing. Although it gives the Kuna easier access to the rest of modern Panama, it also serves as a conduit into Kuna territory for peasant colonists who are being pushed out of the heavily populated interior provinces. Forests within reach of the road have been devastated (7). Subsistence farms are carved into the virgin forest by slash-and-burn techniques (8). The fragile soils beneath the tropical forest are soon so leached that agriculture becomes unprofitable for the colonists, and the land is sold to beef exporters (9). With the trees cleared for cattle grazing, gulleys erode the land during the heavy seasonal rains. Where this is occuring along the El Llano-Cartí road, the land will be soon be virtually useless (10). Each year more and more virgin rainforest becomes arid and barren as cattle ranchers advance steadily into the mountains (11).

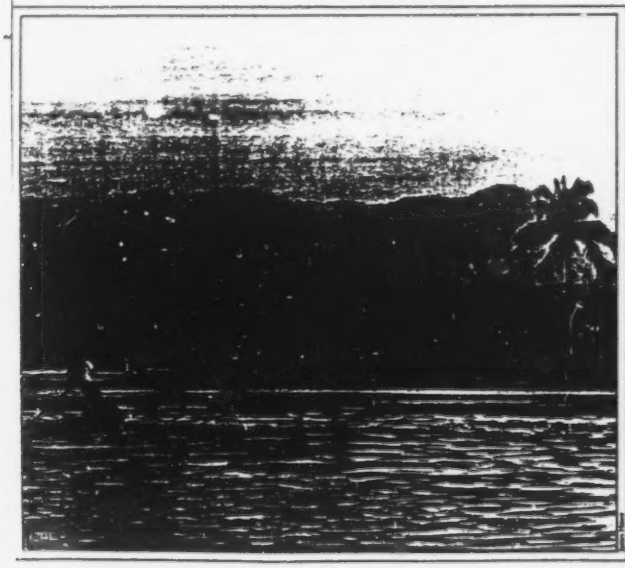




The Kuna have maintained their ethnic and political autonomy through their highly developed sense of organization, which pervades all aspects of community life. Kuna island villages are as tightly knit socially as they are physically (12). Virtually all construction—of individual homes, wharfs, community buildings—utilizes the shared-labor of collective work groups. Nightly meetings—to resolve and discuss major community issues—are held in village congress halls. Chants relating the history of the tribe are regularly performed during these sessions (13). Roll call is taken in the street as a work group discusses a project that is under way. All healthy adult males are expected to participate in this project; those who do not are fined (14). Men set posts for a landfill on the edge of an island village where a clinic will be built (15). Men returning to their boats after working on a communal farm (16).



Standing on a knoll where park facilities will be constructed, Guillermo Archibold —Udirbi's technical director—looks toward the coast of San Blas, more than 20 kilometers away (17). A *nuchu*, or tutelary spirit, standing guard at the gate of the Udirbi Park. These carved wooden figures are traditionally kept in Kuna homes to ward off dangerous spirits (18). The lush forest of the Udirbi Park, located within two hours of Panama City by car, offers both scientists and interested laymen access to an ecologically unique and virtually unstudied area (19). Kuna boy poling his dugout canoe across the shallow coral reefs offshore; in front of him loom the forested foothills, then the mountains of the Kuna reservation (20).



> . . . the Kuna have approached the West more like careful department store shoppers than awe-struck primitives.

the isthmus from the Atlantic to the Pacific coasts. Over the centuries the Kuna have retreated into the Comarca of San Blas—a thin band of jungle running some 200 kilometers along the Atlantic coast, east to the Colombian border. Today, some 30,000 Kuna live spread out among more than 60 villages located on small islands hugging the coast or at the mouths of rivers.

Living in this jungle fastness, which until recently could only be reached by small plane or launch, the Kuna have evolved into the 20th century largely on their own terms. Never conquered nor subjugated, they are the sole masters of their territory. According to Panamanian law, no non-Kuna can hold claim to land within the reservation. While tourists flock to the islands to photograph the Kuna and buy beautiful, reverse-appliqué *mola* blouses, tourism is locally controlled and regulated. If travelers spend the night in San Blas, they stay in hotels owned and managed by Kuna.

Although the Kuna are in many ways insular, they are by no means strangers to the modern world. Since the 1930s, thousands of Kuna men have worked in what was formerly the Panama Canal Zone and in Panama City. Kuna women dressed in their traditional wrap-around skirts, red-and-yellow head scarfs, and exotic mola blouses are a familiar sight on the bustling streets of the capital. And the Kuna are easily the best-educated tribe in Panama, and perhaps in Central America. Many Kuna students study at the National University and abroad, and the number of professionals has grown steadily during the past decade.

At the same time, the Kuna have not been so enticed by foreign ways that they have lost sight of their roots. They govern themselves according to custom, resolving disputes and making decisions in town meetings that are held nightly in most villages and in semi-annual General Congresses of local representatives. These traditional institutions bind the Kuna together as a nation and set the tone for everything in San Blas.

From the very beginning, the Kuna have approached the West more like careful department store shoppers than awe-struck primitives. They have an instinctive ability to search through the wares of Western culture, pick out those ideas and techniques that seem useful, and then tailor them to their own traditions. They approach the world with confidence, assured of their own worth and even superiority. So conscious and proud are the Kuna of their culture, so fluent in discussing it, they can sound at times like a convention of anthropologists. And in all their discussions, the Kuna invariably stress the identification of their culture with a specific expanse of land—the Comarca of San Blas.

"We say that this land is our mother," Leonidas Valdez explained. Valdez is the second-ranking of the three *caciques*, or chiefs, who are the principal spokesmen for the entire Kuna people. "And the land is also the culture. Here are born all things necessary to our culture: the fronds we use for the puberty ceremonies, all the foods gathered for our communal feasts, the materials our artisans use, what goes into the construction of our houses. All of it comes from the forest. If we were to lose this land, there would be no culture, no soul."

A threat to any part of the Comarca is instantly perceived by the Kuna as a threat to their survival as a people. Growing out of a deep-seated respect for the land and a quiet determination to protect it, the Udirbi park is an example of how the Kuna utilize new ideas and techniques to serve old values.

Indeed, greater numbers of policy makers throughout the world are beginning to view their natural resources in a similar light. Until recently, people and governments in many tropical countries consid-

ered their rain forests as obstacles to be conquered if their nations were ever going to break the shackles of poverty and underdevelopment. In Latin America, the pillaging attitudes brought by the avid-for-gold Spanish and Portuguese conquerors in the 16th century have persisted into the present. After much of Latin America won its independence early in the 19th century, its urban intellectuals continued to regard the vast wildernesses of the southern pampas, the wastes of the Chaco, and the great jungles of the Amazon basin and Central America with a mixture of fear and fascination. The wilderness was supposedly the realm of the savage: it was the untamed, backward side of the Latin American character, which the intellectuals contrasted with the civilized traits of the Europeanized city. To the popular imagination, the jungle was dangerous terrain—teeming with mysterious and fatal diseases, predatory animals, and hostile Indians armed with venom-tipped darts. But there too were the futures of their countries, the riches that would one day lift them into the ranks of the wealthy nations. Latin America was the continent of tomorrow, and the path to development would inevitably cut through the wilderness.

Although the rain forests had been penetrated since colonial days in pursuit of gold, rubber, precious woods, cacao, and other riches, a full-scale assault could not be mounted until the middle of the 20th century, when medical advances neutralized most tropical diseases. Equally important, national populations were growing rapidly along with popular aspirations for a better life. Pressures intensified on a land-holding system that left most productive land in the hands of a few rich families. As the clamor for land reform grew, governments sometimes found it politically easier to push colonization of untouched jungle than to attack the basis of economic and political power. During the past three decades, many Latin American countries have embarked on ambitious campaigns to open up their previously almost-inaccessible wilderness areas. Brazil hurled itself into the Amazon basin by carving out a brand new capital city 600 miles inland. Peru envisioned a road east of the Andes that would open up its Amazonian provinces.

In Panama, the zeal for development was personified in the figure of General Omar Torrijos, Panama's strongman ruler from 1969 to 1981. One day, four years ago, his helicopter skimmed over the San Blas rain forest towards a meeting of Kuna leaders on the island of Narganá. The sight of so much virgin forest unpressed Torrijos, and later that day, when he rose to speak in the Congress, he chided the Kuna leaders:

> Why do you Kuna need so much land? You don't do anything with it. You don't use it. And if anyone else so much as cuts down a single tree, you shout and scream.

A Kuna leader named Rafael Harris stood and responded:

> If I go to Panama City and stand in front of a pharmacy and, because I need medicine, pick up a rock and break the window, you would take me away and put me in jail. For me, the forest is my pharmacy. If I have sores on my legs, I go to the forest and get the medicine I need to cure them. The forest is also a great refrigerator. It keeps the food I need fresh. If I need a peccary, I go to the forest with my rifle and—pow!—take out food for myself and my family. So we Kuna need the forest, and we use it and take much from it. But we can take what we need without having to destroy everything as your people do.

According to Aurelio Chiari, administrator of the Udirbi project, who tells the story with great relish, Torrijos was left speechless. He could only stride across the Congress hall and wrap the Kuna leader in an emotional bear hug.

Increasingly, history and scientific research confirm the Kuna view of the rain forest: it is a source for a multitude of beneficial products, but at the same time it is something fragile that must be cared for. As developers lured by visions of great wealth have cut their way through tropical forests, the true ecological vulnerability of those areas has become apparent. To the layman, tropical forests conjure up images of inexhaustible fecundity, of lush, irrepressible growth. Plants spring up overnight, pushing their trunks and stalks a hundred feet into the air and sprouting leaves of elephantine size. The most varied forms of insect and animal life buzz, chatter, hoot, and shriek. Panama, for example, has more species of birds than the United States and Canada combined. A square mile of rain forest can contain as many varieties of plants as all of the British Isles.

Despite this amazing variety, the fecundity turns out to be literally skin deep. Top soil in the jungle is often just inches thick, and because of the constant rain—over 250 inches a year around Udirbi—it is rapidly leached of most nutrients when the forest cover is cut. The towering trees, the thick vines, the giant ferns must all draw their nourishment from shallow root systems that efficiently recycle whatever drops into their maw. It takes only hours for a fallen leaf in the grip of surface feeder roots to decompose back into its constituent elements.

When the forest is cut, left to dry out, then burned, there is a temporary enrichment of the top soil by the nutrient-laden

With a fine sense of geopolitics, the Kuna realized that the point of maximum danger was a place called Udirbi.

ashes. But the continuous cycle of regeneration that supports the rain forest has been sacrificed. Food crops planted by settlers suck up the soil's limited store of nutrients; the tropical rains wash away more; and within three years or so, the soil is exhausted, capable only of supporting grass. If the land is hilly, erosion will soon eliminate even the grass.

Until recently, Kuna lands seemed safe from this specter of a grim and swift passage from jungle to farm to pasture to desert. Although less than 100 miles from Panama City, the Comarca is sheltered behind a mountain range cloaked with almost impenetrable jungle. It was practically inaccessible by land until a branch road from El Llano on the Pan American highway opened about 15 years ago. The road brought a gradual influx of settlers, who opened farms along its flanks. But the real threat first appeared in the 1970s, when the government launched its "Conquest of the Atlantic Coast," a campaign to open up the largely unsettled Caribbean side of the isthmus to landless settlers from the interior provinces. As part of that campaign, the El Llano road would be pushed over the ridge and down the northern slopes of the San Blas to Cartí on the Caribbean coast.

From the start, the Kuna were of two minds about the El Llano-Cartí road. Plane trips from Panama City were becoming ever more expensive as the cost of fuel rose in the mid-1970s, and the journey by launch out of the port city of Colón was lengthy and uncomfortable. The Kuna welcomed the prospect of easier movement for themselves and their goods between San Blas and Panama. But the tribe also worried about encroachments from peasant squatters moving steadily nearer to the southern rim of the reservation. With a fine sense of geopolitics, the Kuna realized that the point of maximum danger was a place called Udirbi, where the new road would enter the Comarca. It was there that they had to establish a presence.

In 1975, Guillermo Archibold, a young leader with experience in agronomy, went to Udirbi with a small group of volunteers to found an agricultural colony. Udirbi, named for a palm tree common in the area, is in premontane rain forest near the summit of the San Blas mountains. When not blanketed with rain clouds, the site offers a spectacular view across more than 20 kilometers of jungle out to the Gulf of San Blas and the densely populated islands of the Cartí group. The terrain is broken, a jumble of steep hills quite unlike the flat, sunnier land near the coast where Kuna farming is concentrated.

Archibold and the volunteers started by planting staple crops—corn, manioc, bananas, and yams. The results were disappointing, so they switched to tree and bush crops—coffee and cacao, peach palm, cashew. Most would not grow in the cool, wet climate; those that did were stunted. Attempts to raise pigs, chickens, and cattle also failed. In early-1981, frustrated, the colonists consulted forestry specialists from the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), a regional agricultural research and teaching center based in Costa Rica. The CATIE foresters soon confirmed what the Kuna had already discovered the hard way: the land at Udirbi was unsuitable for agriculture and would best be left in its virgin state.

It was then that the idea emerged to make the entire top of the mountain ridge at Udirbi into a park. Over the next two years, the Kuna consulted with scientists, foresters, and technicians from a wide variety of institutions: CATIE; the Smithsonian Tropical Research Institute (STRI) in Panama; the Center for Human Ecology in Austin, Texas; the Tropical Science Center in San José, Costa Rica; the Agency for International Development (AID); and the Inter-American Foundation. The foreigners quickly became enthused about collab-

Even as the Kuna reached out for assistance, they made sure the project remained firmly in their control.

oration with the Kuna in developing a forest park, and the project picked up momentum.

Even as the Kuna reached out for assistance, they made sure that the project remained firmly in their control. AID provided funds to train Archibold and his followers in park management at CATIE's headquarters, and during this time a plan took shape. By mid-1983, the Kuna had the key elements in place: they had selected a planning committee of young Kuna professionals and enlisted financial and technical support from local and international institutions. The Udirbi project was launched on a scale that outstripped earlier hopes. What had started almost a decade before as a spontaneous yet vaguely conceived indigenous effort to protect the reservation from invasion had become a full-fledged and complex campaign aided by a prestigious lineup of international allies.*

Though they start from radically dissimilar world views and have become involved in the park for very different reasons, the scientists and the Kuna are discovering that they share a common goal—preservation of the virgin forest along the crest of the Continental Divide. For scientists, the Udirbi park offers a large expanse of previously unstudied forest with a great diversity of unique flora and fauna, including some 80 endangered species.

For the Kuna, the idea of preserving the virgin forest for research is not foreign, even though their rationale differs from that of biologists. They already keep small reserves of virgin forest on land that is often ideal for agriculture and located on the mainland near their coastal communities. According to the Kuna, these untouched reserves are domains belonging to potentially malevolent spirits prone to rise up in anger if their homes are disturbed and attack entire communities. No farming is allowed within the boundary of the spirit domain, and certain of the larger trees may not be chopped down. The Kuna believe that the spirits string their clotheslines in the branches of these trees and become justifiably furious when they are felled. These "spirit sanctuaries" are true botanical parks, since they may be used by medicine men who are gathering herbs.

Not only did the idea of a park at Udirbi fit with Kuna culture; the pragmatic Kuna were also quick to see that it would serve their goal of protecting the Comarca as well as, if not better than, an agricultural community. The main body of the park will cover some 20 square kilometers of virgin forest, with clearly marked boundaries permanently patrolled by Kuna forest rangers. Nine are presently receiving training at the site. Some of the rangers will be Kuna members of the Panamanian National Guard assigned to the park. Others will be trained as guides for the scientists who will eventually visit the site.

Except for technical assistance from CATIE, part of which is financed by the World Wildlife Fund, the entire direction of the park is in Kuna hands. Guillermo Archibold, the young leader who has been involved in the Udirbi project since the first days of the agricultural community, is the park's technical director.

The presently rustic facilities at Udirbi will be improved during 1984 to accommodate scientists willing to rough it to pursue their research. More permanent and comfortable facilities are planned to house between 40 and 50 visitors as well as park personnel. The housing will be built on a high knoll at the original Udirbi site, with its spectacular view. The only infringements on the virgin forest will be nature trails and observation sites and several substations for scientific research. Archi-

*The institutions which are funding the project include the Inter-American Foundation, the Centro Agronómico Tropical de Investigación y Enseñanza, the World Wildlife Fund, the Smithsonian Tropical Research Institute, and the Agency for International Development.

> "That's the beauty of working with the Kuna. If their Congress accepts an idea like this, then they'll do it."

tects are working closely with project staff to develop a design for the new buildings that will fit into the environment and reflect native culture.

These new facilities will serve not only scientists engaged in research projects, but a special kind of visitor the Kuna hope to attract—the "scientific tourist" drawn by the uniqueness of the region, the great beauty and variety of the plant and animal life. Bird watchers, for example, are most definitely welcome.

Thanks to the new road, the park will offer scientists and visitors an unusual combination: a pristine rain forest that is only two hours from a major city with a busy international airport. For scientists, an added bonus includes nearby laboratories and photographic-processing and communications facilities—much of which has grown out of the presence in Panama for more than 60 years of the Smithsonian Tropical Research Institute.

"There is a great unexploited potential for scientific tourism in Panama," said Ira Rubinoff, STRI's director. "Because this is a narrow isthmus, there is an enormous concentration of species of animals and birds. The bird flyways are funnelled through here. There are few places like this left in the world, and the great attraction, of course, is that there is a good prospect for this being saved. That's the beauty of working with the Kuna. If their Congress accepts an idea like this, then they'll do it. You can count on it."

Brian Houseal, a young park management specialist who works as full-time consultant for the Udirbi staff, emphasized that the Kuna's new park will not only preserve virgin forest and facilitate basic research but also will provide unique opportunities for applied studies of agricultural techniques appropriate to tropical areas. "Again, there's so much we need to learn," he says. "The models of land use now current in the tropics are really not suitable. Some temporary use is gained from the land, but the end result is destruction. You just have to look at the other side of these mountains to see that. We need to study the techniques used by groups like the Kuna, who have lived in these areas for centuries without destroying them. They've developed technologies that are appropriate for tropical agriculture."

"We must control this chaotic use of tropical land," Rubinoff says. "The Comarca is a good example of using the tropics in a planned way. There are areas, like the park, which should be a reserve. There are other areas that are perfect for agriculture. But we need to learn how to use that land. At least now we know that the way to approach tropical lands is through seduction, not rape."

The Kuna, of course, have always known that. When the Kuna stand on their home islands and contemplate the jungle-shrouded slopes of the Comarca, they gaze, according to oral traditions, at the "green-clothed" body of the Great Mother, who is the Earth. Those histories say that in the beginning she came naked. Her union with the Great Father produced all of the vegetation—which became her "garments"—the animals, and finally humans. Each season, the Earth replenishes her supplies of living things: plants grow and flower, and yield fruit; fish are delivered from the Earth's body in rain-choked rivers and turbulent seas; and animals fall from the clouds that float low over the jungle. The act of periodic regeneration, together with nurturing and maternal protection, are themes that find expression throughout Kuna culture. If the Udirbi project ultimately succeeds in preserving the virgin rain forest of San Blas for scientific study and for future generations, the main reasons will be the Kuna's careful husbandry of their values and their special relationship with the land—reverential, affectionate, and intensely personal.

PATRICK BRESLIN is a writer who has lectured and published extensively on Latin America. His two novels are Interventions *and* The Whalebone Gate *(forthcoming, 1985). He holds a doctorate in political science from the University of California at Los Angeles. MAC CHAPIN is an anthropologist who is IAF representative for Panama. He was a Peace Corps volunteer on the San Blas Islands and returned there for his doctoral research on curing among the Kuna. His article, "Udirbi: An Indigenous Project in Environmental Conservation," will appear in a forthcoming special publication of* Cultural Survival.

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Nicholas Guppy

TROPICAL DEFORESTATION: A GLOBAL VIEW

Tropical rain forest, today everywhere threatened with accelerating destruction, if conserved could be one of humanity's greatest renewable resources. In 1982 it occupied nearly 12 million (11,610,350) square kilometers of the continuously warm, high-rainfall areas of the globe that lie between the tropics of Cancer and Capricorn. Wherever it remains it forms a three-dimensional carpet, 40 meters or more thick, of intricately interwoven and interdependent individuals of several millions of species (including both plants and animals), and many life-forms—more than are found in any other terrestrial ecosystem. Its preservation is important for many reasons, but perhaps the maintenance of this genetic diversity is ultimately the most important, because it offers endless opportunities for mankind, and because it is irreplaceable.

More obviously, however, rain forest is a source of raw materials: timbers for construction, furniture, plywood, paper, and other uses; fuelwoods, fibers, canes, resins, oils and drugs; fruits and spices; and much else. It is also functionally important. Considered as a solar engine, it absorbs more sunshine than any other living land cover, moderating surface temperatures and reducing heat reflection into the atmosphere. It uses this absorbed energy to combine atmospheric carbon dioxide gas with water to form sugars and starches, oils and fats; and later, adding mineral salts and other

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Nicholas Guppy, now living outside Cambridge, England, has been a close student of tropical rain forests for more than 35 years, with extensive early travels especially in British Guinea and the areas north of the Amazon. He was a research assistant of the New York Botanical Garden for two years; advised Daniel K. Ludwig upon his Venezuelan property, and *Life* magazine upon "The World We Live In"; edited the Macdonald Nature Encyclopedia with Sir Julian Huxley; and was then head of Granada Television's Natural History Film Unit.

Between 1970 and 1980, Mr. Guppy traveled extensively throughout the New World and Far Eastern tropical forest regions, and in other areas of the globe. In 1980 he began writing about the problems of tropical deforestation (in association with the Threshold Foundation). He was consultant and co-author of the Time-Life book *The Amazon*, and has contributed to learned journals and books upon conservation, ecological and social themes. The author acknowledges with especial gratitude the encouragement and advice of William D. Rogers of Washington, D.C., and of Dr. Timothy C. Whitmore of Oxford University. Copyright © 1984, Nicholas Guppy.

substances, to make proteins and innumerable complex materials; as a by-product, it is the largest terrestrial net producer of oxygen. It imbibes rainfall and ground water, and holds water close to the earth's surface, releasing it slowly into aquifers or as runoff into river systems, or transpiring it from its leaves into the atmosphere as water vapor, which later provides rain in other areas (over 50 percent of rainfall in Amazonia comes from such forest transpiration). The roots that anchor the forest to the ground stabilize soils, protect the landscape from wind and water erosion, desiccation and floods, and filter and purify water supplies: successful agriculture in the tropics often depends upon the maintenance of natural forest nearby.

For many years there has been alarm at the rate of rain forest clearance. But until a year ago there were no generally accepted figures for the size of the remaining areas in the 76 or more tropical rain forest countries, or for the rates at which they were being destroyed. Table I, "The Principal Tropical Forest Countries," on the following page, gives these areas and defines the forest types discussed herein as "rain forest." Today accurate, clearly explained figures for the major categories visible in satellite photographs are available as a result of the several years' work of the Tropical Forest Resources Assessment Project of the Food and Agriculture Organization of the United Nations (FAO).[1] These results have been summarized by J.P. Lanly, whose global figure for the area being cleared each year is 157,000 square kilometers (about the area of England and Wales combined).[2]

A world without the myriad plant and animal lives of rain forest, without the wonder and beauty it contains, would be immeasurably poorer. Yet unless we can halt this destruction, straight line projection gives a date 73 years ahead (2057) for the final demise of this currently still vast, irreplaceable sector of our planet. Spiraling population growth, rising consumption of timber and forest products, or demand for new agricultural land, could all bring this date nearer—even to the point where rain forests would be doomed within 20 years. War or pandemic could affect the trend, as could protectionism. Better by far, however, would be cooperative rational action with the aim of ensuring that natural rain forest is safeguarded in perpetuity.

It is inconceivable that technology or engineering could replace

[1] "Forest Resources of Tropical Africa"; "Forest Resources of Tropical Asia"; "Los Recursos Forestales de la America Tropical"; Tropical Forest Resources Assessment Project, Rome: Food and Agriculture Organization, 1981.

[2] Jean-Paul Lanly, "Tropical Forest Resources," FAO Forestry Paper 30, Rome: FAO, 1982.

TABLE I

THE WORLD'S PRINCIPAL TROPICAL FOREST COUNTRIES BY AREA
(in square kilometers)

Country	National Area	Undisturbed Forest	Logged/Managed Forest	Unproductive Forest	Total Forest Area	% World Total
Brazil	8,511,965	2,886,300	120,000	556,500	3,562,800	30.68
Indonesia	1,903,650	389,150	946,600	400,000	1,135,750	9.78
Zaire	2,345,409	797,400	3,800	255,300	1,056,500	9.09
Peru	1,285,215	375,200	60,000	259,900	695,100	5.97
Colombia	1,138,914	386,000	9,000	69,000	464,000	3.99
India	3,166,828	48,850	334,750	76,860	460,440	3.96
Bolivia	1,098,580	177,600	120,900	141,600	440,100	3.79
Papua New Guinea	475,300	138,150	2,200	196,750	337,100	2.90
Venezuela	912,050	76,000	116,100	126,600	318,700	2.74
Burma	678,030	141,070	90,090	80,770	311,930	2.68
Cumulative Total		5,415,720	1,203,420	2,163,280	8,780,420	75.62
And 63 Other Countries		1,270,430	720,350	838,550	2,829,930	24.39
World Total		6,684,150	1,923,770	3,001,830	11,610,350	100.00

NOTE: Figures are for Broad-Leaved Humid and Dry Forests with closed canopy; Coniferous and Bamboo Forests are excluded. "Unproductive Forests" may be so designated for physical or legal reasons.

After the ten countries listed above, the following 20 countries have the highest areas of tropical rain forest: Mexico, Congo, Malaysia (all), Gabon, Guyana, Cameroon, Surinam, Ecuador, Madagascar, Philippines, French Guiana, Thailand, Laos, Vietnam, Kampuchea, Nigeria, Ivory Coast, Nicaragua, Panama, Paraguay.

Countries omitted from estimates: Africa—Mali, Niger, Upper Volta; Pacific—Solomon Islands, Fiji, Vanuatu, New Caledonia; Americas—Smaller Caribbean Islands.

SOURCES: Forest types and Areas from *Tropical Resources Assessment Project*, Rome: FAO, 1981. Country areas from John Paxton, ed., *The Statesman's Yearbook, 1983-84*, London: Macmillan, 1983.

the functions that rain forest performs for us free, without human input of energy, time, money or materials—let alone substitute for the materials that it manufactures. Already loss of rain forest puts a strain on us when we have to repair a watershed, stabilize an eroding hillside, flood-control a river, or purify the atmosphere—all of which are becoming commonplace activities wherever natural self-maintaining systems are locally overloaded. The scale and pressure of human demands on the environment is little appreciated, and it is growing: in 1975 every single man, woman and child in the United States used on average 40,000 pounds of *mineral* matter alone—of stone and cement, sand, gravel, natural gas, iron and steel, salt, petroleum, non-ferrous metals, coal and clay[3] quite apart from huge quantities of other materials—agricultural products, timber, marine life, water, and much else. And all this was used in commonplace ways—just in making buildings, roads, furniture,

[3] Gerald O. Barney, Ed., *The Global 2000 Report to the President: Entering the 21st Century*, Vol. 1, London: Penguin Books, 1982, p. 384.

packaging, hamburgers, automobiles, newspapers, refrigerators, clothing, shampoos . . . things we take for granted. Some of these raw materials derive from renewable production; but the majority represent destruction of the environment *somewhere*. Per capita demand is much less over most of the world, and so is total demand, often despite higher population densities. Over large areas of the tropics, demand for exports to the United States, Western Europe and Japan is the preponderating factor in rain forest and environmental destruction.

The potential consequences of *total* rain forest destruction have attracted wide and serious discussion. They include, beside the loss of genetic material previously mentioned (and further discussed in Section V), dire environmental effects: massive erosion and landscape degradation in the wet tropics, causing a decline in agricultural productivity; population collapse, beginning in Southeast Asia around A.D. 2000 through starvation and disease, and spreading elsewhere later; and eventually a rise in sea level, caused by melting of the polar ice-caps due to increasing atmospheric carbon dioxide, which would act as a blanket and trap heat near the earth's surface. Tropical rain forests and their soils contain 20 percent of the world's terrestrial carbon pool of 500 billion metric tonnes, 46 percent of it in the living forest, and most of this is released as carbon dioxide when forest is destroyed.[4] Even more CO^2 would be released if the vast volumes of the gas dissolved in the oceans were suddenly to come out of solution as sea temperatures rose.[5] There have been various estimates of how rapidly this sea-level rise would occur; but eventually it could inundate the world's most populous and industrialized lowlands, and all of its largest cities.

To mention such possibilities, which rank with those of nuclear war, may seem alarmist. Yet disasters of equivalent magnitude have occurred in historical and recent prehistoric times, as the ruined desert cities of North Africa and Asia testify; or the fact that the Bering Straits and the English Channel were dry land only a few thousand years ago. No global model incorporates environmental factors adequately. Yet all predict critical, even catastrophic times ahead as populations grow, and as demand and the ability to exploit

[4] Sandra Brown and Ariel E. Lugo, "The Storage and Production of Organic Matter in Tropical Forests and their Role in the Global Carbon Cycle," *Biotropica*, Vol. 14, No. 3, September 1982, pp. 161–187.

[5] For discussions, see F. Kenneth Hare, "The Planetary Environment, Fragile or Sturdy?", *Geographical Journal*, November 1980, pp. 378–395; William W. Kellogg and Robert Schware, "Society, Science and Climatic Change," *Foreign Affairs*, Summer 1982, pp. 1078–1110; Philip Stewart, "Forestry for Carbon Dioxide Fixation," *Commonwealth Forestry Review*, Volume 57, No. 4, 1978, pp. 263–266.

resources increase. In the destruction of tropical rain forest a crisis-point may be approaching between human activity and life-support systems. We have modified human behavior sufficiently in the case of nuclear warfare to have achieved a modus vivendi for several years, if not yet the long-term certainty of peace. Rain forest destruction is an even more complex and challenging issue, because it is closely interwoven with so many seemingly intractable problems—social, political and economic.

II

Discovering the reasons for the sudden dramatic acceleration in rain forest destruction is like slicing into a multilayered cake. On the surface, obvious factors include population growth; the increased need for land for agriculture, stock-raising and settlement; the wish to raise capital for development; and a rapidly growing demand for timber, fuelwood, and other forest products.

Yet when we look carefully we find that these are not necessarily decisive, or even important causes. Underneath are other layers—of social mores, of political expedients, of national and global economics, and of ideological conflict. Indeed today, almost everywhere, destroying rain forest is a means of *avoiding* tackling real problems by pursuing chimeras: a "license to print money" which yields quick cash at the cost of ultimate catastrophe. Each time we read of floods, landslides, starvation, and loss of life in India, Brazil, the Philippines, Haiti, East Africa, and elsewhere in the tropics, we are reading about problems caused or exacerbated by environmental destruction, often of rain forest.

One of the chimeras pursued by planners is the belief that if land can grow trees it can grow crops. Two thousand years ago most of Europe and China was sparsely inhabited and covered by thick forests. Today, in their place, lush farmlands support huge civilized populations, with only occasional patches of forest remaining. To the ignorant, and to wishful thinkers in less-developed countries, the felling of tropical rain forests marks the end of backwardness and the beginning of a similar process of enrichment. This is an understandable viewpoint. Indonesia, for example, has a total land area of 1.9 million square kilometers of which 60 percent is under dry-land forest, while tidal swamps (largely mangrove forest), heavily eroded hill slopes, and impoverished alang-alang grassland occupy another 30–45 percent, leaving a population of 152 million to live on a mere five to ten percent of her land surface.

At higher altitudes where the climate is cooler; where rainfall is seasonal (so that during part of the year nutrients are drawn up

from below by evaporation and capillarity, instead of just being washed away); and in alluvial and volcanic areas of the rain forest zone, are found rich, permanently cultivable soils that are among the most fertile known. In central Java they support 1,500 persons per square kilometer; in the Mekong Delta, 350—the densest agricultural land populations anywhere. Unfortunately nearly all such rich soils have already been known for centuries, cleared of forest, and cultivated. Population maps show exactly where they are: alongside the crowded parts of Java are thinly settled regions; small, teeming Madura is next to vast unpeopled Borneo; the Andes valleys are thickly inhabited, while in the forests of Amazonia, alongside, the population density is about ten persons per square kilometer, or even less (two in adjacent formerly forested savannah areas).

According to the World Bank, less than ten percent of existing rain forests are growing on such rich soils.[6] It would be fortunate indeed if we knew their location. Then deliberate deforestation, large-scale settlement, cultivation and ranching could be confined to these approximately 1.16 million square kilometers. On the remaining 90 percent of tropical forest lands, a population of no more than about ten persons per square kilometer (i.e., about 100 million in all, worldwide) can live. They can practice shifting cultivation, together with a little small-scale hunting, logging, charcoal burning, and collecting of forest products. But any greater degree of exploitation, and any conversion to other uses, would cause permanent damage and loss of productivity to these lands—the eroded hill-slopes, the alang-alang grasslands (or their local equivalent), which already occupy huge formerly forested areas in Indonesia where the poor and hopeful have tried the experiment in the past. In a word: impoverishment, local and national, will result. And this is what is being created, accidentally or through misguided policies, as deforestation proceeds in many parts of the tropics.[7]

The nature of soil weathering under rain forest conditions was first brought home to me sharply some 35 years ago in a gold mine in the interior of Guyana: "We descended 300 feet by lift, and on our way I noticed that weathering of the solid rock had taken place down to 60 feet below the surface in this hot and humid climate, instead of at the most 2 or 3 feet, as in England. At this depth what looked like solid feldspar crystals were soft as butter, the granite

[6] John S. Spears, "Small Farmers—Or the Tropical Forest Ecosystem?", paper presented at International Forestry Symposium, Yale, 1980.

[7] Robert J.A. Goodland, *Amazon Jungle: Green Hell to Red Desert*, Oxford: Elsevier Press, 1975.

itself merely clay containing sand grains."[8] Remove the tree cover, and on steep slopes heavy rain would sweep away those 60 feet of soil and perished rock in a few months, leaving gulleyed badlands.

Tropical forests are able to thrive on exceedingly poor soils because their plants have evolved ways of capturing and holding nearly all the nutrients that become available: tree roots are superficial, and sometimes actually rise above ground level to penetrate directly into fallen logs; while the fungi digesting dead leaves exchange nutrients with adjacent trees. Under rain forest conditions, as I saw in my descent down the mine shaft, silica is dissolved preferentially out of the underlying rock, and iron oxide, alumina, magnesia and other minerals accumulate—hence the bright red and yellow colors of tropical "lateritic" soils, which typically have adequate nitrogen but usually little calcium, potassium, and phosphorus. However, huge areas of tropical soils consist of almost pure silica to begin with, being the fossil sands of ancient seas; weathering leaves these white or pale colored, and very low in nitrogen.[9] In either case the nutrients are mainly in living or rotting material, and not in soil humus. When the forest is felled, decay is swift and nutrients are rapidly leached away by the torrential rains—as are any fertilizers applied.

In Malaysia, under such conditions, hill rice yields fall from 100 percent in year one, to 47 percent in year three; in Zaïre, from 100 percent to 24 percent in two years. Experimentally, various attempts to achieve continuous cultivation have been tried on forest soils with different degrees of success. For example, a multiple-cropping system which never leaves the surface bare works well in Indonesia, on the comparatively rich red and yellow podzolic soils which cover about 15 percent of the country's area, and which are mostly grassland, formerly forested. But this involves heavy and skillful applications of artificial fertilizers, and can only be used where prices for the crops produced will sustain their purchase.[10]

In general, on poorer forest soils the best—and indeed only—suitable farming methods are those that have been evolved almost uniformly throughout the tropics by tribal peoples. Typically they clear a patch of forest, cultivate it for two or three years; then move on, fell, clear and plant another area—the system known as slash-

[8] Nicholas Guppy, *A Young Man's Journey*, London: John Murray & Co., 1973, p. 167.

[9] Peter Grubb, lecture to the Cambridge Philosophical Society, 1983; John Proctor, "Mineral Nutrients in Tropical Forests," *Progress in Physical Geography*, Volume 7, No. 3, 1983; E.C.J. Mohr, F.A. van Baren, and J. van Schuylenborgh, *Tropical Soils: A Comprehensive Study of their Genesis*, The Hague, Paris, Djakarta: Mouton-Ichiar Baru-Van Hoeve, 1972.

[10] Gordon R. Conway, Ibrahim Manwan and David S. McCauley, "The Development of Marginal Land in the Tropics," *Nature*, Vol. 304, August 4, 1983, p. 592.

and-burn, or shifting cultivation. This might seem destructive, but the small fields are ecologically similar to natural gaps in the forest, which remains all around to recolonize them and restore fertility to the soil.

These natural gaps form part of the development cycle of rain forest, which consists of a mosaic of three phases, each with its own distinctive characteristics and plants.[11] If we are to learn how to utilize this ecosystem for our own ends, we must understand how the processes of destruction and re-creation operate in these phases.

In the Gap phase, which occurs when a tree falls, there is negative productivity as the tree decomposes. This is followed by the Building phase, during which productivity is higher, these two phases occupying about ten percent each of any given undisturbed area. Finally, the Mature phase is reached, typically occupying about 80 percent of the total area, in which productivity levels off and remains low for many years until trees die and create new gaps. This Mature phase is what most people envisage as typical rain forest; it occupies most of the area most of the time, and though lower than the Building phase in "biomass" productivity (net dry weight or volume of trunks, branches, roots, leaves, etc. produced), qualitatively it has far more species and materials, and provides the greatest environmental protection.

The overall productivity of rain forest (including all of these phases) has not been convincingly estimated for any large area, but figures as low as 3.5 and up to 28–32 tonnes per hectare per year have been found.[12] In Venezuela, Peter Grubb made accurate measurements in several kinds of natural forest growing on rather poor soils, and found a total above-ground biomass productivity per year from 10.5 to more than 16 tonnes per hectare. After clearing, when fertility was greatest, manioc yielded a mere 1.8 tonnes.[13] But manioc is directly usable by man, and at present much of forest biomass is not, however valuable it may ultimately prove.

When a natural gap occurs, or a slash-and-burn field is abandoned (or an area clear-felled), the first new plants of the Building phase to appear are herbs, vines, and the seedlings of trees which produce abundant light and often wind-blown seed. Efficient colonizers, these are often regarded as "weeds," and are found only in gaps or at riversides, because typically they are "light-demanders," intol-

[11] T.C. Whitmore, *Tropical Rain Forests of the Far East*, Oxford: Clarendon Press, 1975; new edition 1984.

[12] Carl F. Jordan, "A World Pattern in Plant Energetics," *American Scientist*, Vol. 59, 1971, pp. 425–433.

[13] Peter Grubb, *op. cit.*

erant of shade (or they would already be thriving under the forest), and very fast growing. Soon the larger species begin to push through this tangle—commonly trees of genera such as *Cecropia*, *Ochroma* ("Balsa"), *Musanga*, *Macaranga* and *Trema* in different parts of the tropics—in stands often of a single species. Within 7–15 years they form a pioneer forest with a closed canopy up to 12–16 meters high.

Under this canopy, shade-tolerant slower-growing species with heavier wood begin to appear, usually derived from larger seeds with abundant food reserves. Such seeds and their seedlings have a long life, but are often slowly dispersed—they may only be capable of spreading a few feet every hundred years. In about 50–80 years they consolidate to form high "second growth," perhaps 25 meters tall, containing a much larger mixture of trees with medium or heavy woods.

So long as their seedlings or seeds are present (or arrive), trees of the original Mature-phase rain forest will also begin to appear, as conditions for them become suitable, and eventually these overtop the "second growth" and form a closed canopy 40–55 meters above ground. After 150 years most of the large trees of the regrown area will be those of the Mature phase, but it may take up to 400 years before all the original components have reassembled: the smaller trees of lower layers, the shrubs, herbs, lianes and epiphytes, and the vast and varied fauna of mammals, birds, reptiles, insects, mollusks, and other forms of life. The final stages of reassembly are the slowest, because as this complex society develops, fewer and fewer opportunities, or "niches," are left—and there must be Mature-phase forest close by from which they can be recolonized. To retain rain forest, therefore, we must treat it with respect, for each area of the world has its unique constituents; once lost, they are gone forever; and even if not lost, take hundreds of years to reassemble.

Accurate analysis of these stages, and of their accompanying soil and microclimate changes, and of the roles of the different species in them, is lacking. It should enable us one day to modify this mosaic to our greater advantage, without the current destructiveness, and possibly increase the population that forest areas can carry. Often trees of the Building phase have lighter, more workable wood than those of the Mature-phase forest, and as they grow faster these are the species usually selected for growth in plantations—and sometimes described as "miracle" trees: Gmelina will grow to a size suitable for harvesting in 7–12 years; Caribbean Pine or Eucalyptus in 15–25 years; teak in 60–80 years, *once*. But fast

growth depletes soil nutrients and moisture, and affects soil structure, and growing a second or third crop on the same site becomes agriculture, with fertilizers necessary as yields drop dramatically.[14] In converting rain forest to agriculture, tree or shrub crops (such as citrus, bananas, mangoes, coffee, cacao, oil palm, rubber, etc.), tree plantations, ranching, or even the various mixtures of agriculture and forestry known as "agroforestry," we are in effect trying to isolate the Building phase and take advantage of its superior productivity; and this we cannot do sustainably on the poorer soils. And this is only to be expected, for their rain forests have evolved to utilize the natural inputs of these sites through thousands of years of optimization.

If, after felling, there is a "forest fallow" period during which the field or gap is allowed to regrow as natural forest to the Mature phase, no permanent damage is done. But where recultivation is more rapid, and the forest that returns never gets beyond the Building phase, there is immediate loss of soil nutrient status, of diversity and of environmental benefits. Nor is there any guarantee that these can be recovered. And if the frequency of clearing and cultivation is further increased, usually because of population pressure, the forest simplifies yet more, until a scrub of "weed" species or impenetrable tall grass takes over, and soil drying and degeneration are swift. Burnings hasten the process, and desert can be the end result. In Indonesia alone over 15 million hectares are covered with *Imperata cylindrica* grasslands, while in Java and Bali 40 million hectares are badly eroded, all as a result of deforestation. Throughout the tropics such wastelands are spreading, and they will continue to spread so long as the developmental sequences which bind together soil, landscape and plant life are ignored.

III

Land hunger is often proposed as a major cause of deforestation. Indeed, over half the world's population lives within the rain forest zone, in areas formerly forested (Table II), and still relies in part upon forest products, most importantly for fuelwood (half of all wood cut; four fifths of that cut in the developing world). The majority are materially very poor by Western standards, but seldom starving or destitute. The 420 million malnourished absolute poor[15] live mostly in low rainfall, poor soil, scrub and semi-desert areas of

[14] E.D. Chijioke, "Impact on Soils of Fast Growing Species in Lowland Humid Tropics," Technical Paper (Forestry), No. 21, Rome: FAO, 1980.

[15] "Agriculture Towards 2000," Rome: FAO, 1979.

TABLE II

POPULATIONS OF THE WORLD'S PRINCIPAL TROPICAL FOREST COUNTRIES

Country	Population	Annual Increase	In 2000	Per Capita GNP ($ U.S.)
Brazil	123,030,000	2.3%	187,494,000	1,770
Indonesia	151,891,000	2.3%	198,687,000	370
Zaire	28,290,000	2.7%	49,982,000	210
Peru	17,780,000	2.7%	30,703,000	850
Colombia	27,520,000	2.3%	37,999,000	1,060
India	683,810,000	2.1%	960,611,000	210
Bolivia	5,600,000	2.6%	9,724,000	550
Papua New Guinea	3,080,000	2.3%	5,179,000	760
Venezuela	13,910,000	3.4%	27,207,000	3,440
Burma	36,170,000	2.2%	55,108,000	150
Total	1,091,081,000		1,562,694,000	
Total World Population	4,735,000,000		6,118,850,000	

SOURCES: International Monetary Fund, *International Financial Statistics Yearbook 1982*, Washington, 1982; United Nations, *World Population Prospects as Assessed in 1980*, New York, 1981; World Bank, *Atlas of Gross National Product, Population, and Growth Rates*, Washington 1981; Norman Myers, *Conversion of Tropical Moist Forests*, Washington: National Academy of Sciences, 1980; John Pastore, ed., *The Statesman's Yearbook 1981-82*, London: Macmillan, 1981.

Africa, Asia and South America—areas which in several instances have been forested historically.

Within the rain forest itself live some 696 million people,[16] who are dependent upon the forest entirely for their livelihoods. They are not evenly distributed, living mostly round the edges of the main forest areas. In regions with low agricultural populations (less than one person per ten hectares of trees), such as Papua New Guinea, Central Amazonia and the Guianas, central and southern tropical Africa, and the Caribbean Community countries, the forest is least under pressure; in those where agricultural populations average more than one person per two hectares of tree area, such as tropical Asia, Central America, and the savannah fringe areas of West, Central and East Africa, the threat is greatest.

Some of these people belong to forest-dwelling tribes, but the majority are encroaching settlers, and it is commonly said that these are the chief cause of rain forest destruction. But this is not so, for between half and two-thirds of them live in already damaged "Second Growth" or logged forest, because undisturbed rain forest is seldom accessible except where it has been opened up by logging roads. Nonetheless their destructive impact is great, because they

[16] Estimated from Lanly, *op. cit.*, pp. 34–35.

shorten the forest-fallow period, and as they advance they convert productive areas to scrub and grassland. These encroachers have a low population growth rate (1.58 percent per annum) compared with the average for their countries (2.6 percent).[17] By 2000 they will have increased to some 925 million, while new settlers will raise the overall total yet further—unless government policies in several nations are reversed. If uncontrolled they will occupy half of the total forest area that exists today.

John S. Spears examined this problem and concluded that 200 million of these people (40 million families) could be permanently settled on 1.3 million square kilometers of better forest land (giving about 1.5 hectares per person) at a cost of between $5,000 to $20,000 per family, or about 50 times the average encroacher's annual cash income—his costs being based upon those of actual World Bank agricultural settlement schemes.[18] The total cost of Spears' scheme is thus $200 to $800 billion, while a scheme to settle all forest encroachers by A.D. 2000 would cost $700 to $2,790 billion, or between $40 and $165 billion a year. Spears concludes that "dependent on the situation, investment of the same amount of money in improving agricultural productivity outside the forest areas may well benefit more people at lower cost."

It is here that we begin to slice deeper into the multi-layered cake of deforestation causes. For though much forest colonization is spontaneous, more often it proceeds with government encouragement, as it provides a convenient safety valve for land hunger and social discontent. Almost none of it, however, is occasioned by a genuine shortage of new land.[19]

In Brazil, for example, outside of Amazonia—the area drained by the River Amazon and its tributaries—there is enough good, permanently cultivable land to give 2.3 acres to each individual Brazilian, and ten acres to each family—more such land than is available in the United States. Yet as a result of government policies disadvantageous to small farmers, smallholders are selling up and moving elsewhere (in Paraná state 40 percent of the smallholders of just one municipality left in 1982).[20] Fifty percent of farmers today own only three percent of farmland, while 43 percent of farmland is owned by one percent of farmers. Many of the larger holdings of de-peopled high quality farmland, which are mostly in

[17] Lanly, *op. cit.*

[18] Spears *op. cit.*; and "Can the Wet Tropical Forest Survive?", *Commonwealth Forestry Review*, Vol. 57, No. 3, 1979, pp. 1–16.

[19] Val Plumwood and Richard Routley, "World Rainforest Destruction—The Social Factors," *The Ecologist*, Vol. 12, No. 1, 1982, pp. 4–22.

[20] Adrian Cowell, "The Decade of Destruction," Central Television, Manchester (U.K.), 1983.

southern Brazil, are today underused, or even unused, being held for investment by corporations and absentee landlords whose main business is elsewhere. And ironically large tracts of this farmland are now being commercially reforested. Brazil thus has a real problem of land hunger in the midst of plenty.

To meet this self-inflicted need, the rain forests of Amazonia in the north of the country were opened to colonization in the 1960s; the vast Amazonian basin, which includes some 40 percent of Brazil's national area, is mostly heavy forest, though there are some areas of relatively thin forest and savannah (prairie). The "New Frontier" was promoted in a fever of nationalist enthusiasm. "E Brasil Gigante" read the t-shirts: Amazonia must be peopled with good Brazilians, not just Indians—to whom, under Brazil's laws, most of the land belongs. Where not deliberately murdered or evicted, measles and other introduced diseases have killed up to 100 percent of the Indians contacted in this process, and time and again Indian reservations and park boundaries have been altered.[21] Amazonia must be traversed by roads to provide infrastructure and facilitate settlement, but also "for easier defense against invasion," a general told me in 1972 (as if unbroken forest is not a better defense?), "and against insurgents." Highway construction was started in 1968, and funded in large part by outside agencies: the U.S. Department of State, the U.S. Agency for International Development, the Inter-American Development Bank, the World Bank, and direct U.S. Army aid to the Brazilian Army Corps of Engineers.

Between 1966 and 1975, 11.5 million hectares of forest were cleared. Small parcels of forested land were (and still are) given free to settlers, while larger areas of 2,000 hectares or more of better land could be bought for around five dollars (today, $20 to $35) per hectare. Wave after wave of immigrants arrived, enticed by hopes of a new life on their own property.[22] Most failed because of the poor soil (only two percent of Amazonia's soils are perma-

[21] Shelton Davis, *Victims of the Miracle*, Cambridge, 1977; Nicholas Guppy, "Some Crucial Issues of Our Time," *Environmental Conservation*, Vol. 7, No. 1, 1980, pp. 3–8; Robin Hanbury-Tenison, *A Question of Survival for the Indians of Brazil*, London: Angus and Robinson, 1973; Norman Lewis, "Genocide," *The Sunday Times Magazine*, London, February 23, 1969; World Bank, "Tribal Peoples and Economic Development: Human Ecological Considerations," Washington: World Bank, 1982. Discussion of current aspects of this issue can be found in *Cultural Survival Quarterly*, published by Cultural Survival Ltd., Cambridge (Mass.), and *Survival International News*, published by Survival International Ltd., London.

[22] George Martine, "Recent Colonisation Experiences in Brazil: Expectations Versus Reality," in *Land, People and Planning in Contemporary Amazonia*, ed. F. Barbira-Scazzocchio, Cambridge (U.K.), 1980; Samuel Benchimol, "Population Changes in the Brazilian Amazon," contribution to *Change in the Amazon Basin*, symposium of the 44th International Congress of Americanists, Manchester (U.K.), 1982; Davis, *op. cit.*

nently cultivable), and many ended up as laborers on the ranches that mushroomed. For at such low land prices it was profitable for larger-scale investors to buy land, often in big blocks, clear-fell, sell the few trees worth the trouble of extracting, and burn the rest; then sow grass and bring in cattle, despite the fact that the land proved able to sustain only about one head per 2.5 hectares on average, and that the average life of each ranch is a mere two to seven years before it has to be abandoned due to weed growth, erosion, and loss of nutrients.[23] During the ten years to 1975, peasant colonization over the whole of Amazonia cleared some two million hectares—less than half the amount of forest obliterated by ranching in one state alone in three years. Sixty percent of clearance was done by highway developers (3,075,000 hectares) and cattle ranchers (3,865,271 hectares), and only 17.6 percent by peasants. Today Amazonia still contains only four percent of Brazil's population; there is abundant cheap labor on the surviving ranches, and in retrospect the colonization scheme looks almost like a costly and destructive Machiavellian plot to procure it!

By 1976 failure was apparent in central Amazonia. Government settlement planning then focused on the seasonal forests of Rondônia, in the southwest of the region, where the old pattern is repeating itself in unabated stupidity. Colonists are given 50 hectares each, laid out in grid patterns with no regard for soil quality (much is unfarmable), availability of water, topography, or the legal rights of its Indian and Caboclo (existing forest peasant) inhabitants. By 1983, 70,000 settlers a year were arriving, and 80,000–90,000 are expected this year, lured by the offer of free land, government-guaranteed minimum prices for crops, and title-deeds—granted only after a percentage of land has been cleared of forest.[24]

Already, as in all other deliberately colonized parts of the Amazon Basin, immense and irreversible environmental damage has been caused, involving a vast reduction in capital resources, and of potential income. Brazil imports two thirds of its rubber, but could be self-sufficient from the forests being felled and burnt (rubber-tappers earn as much as the best-paid factory workers); fish which breed in the forests when they are flooded produce more protein per hectare than cattle; and wild produce such as Brazil nuts are more valuable than the settlers' crops. Even more remarkable, Rondônia imports nearly all its fuel, including gas for cooking,

[23] Harald Sioli, "The Effects of Deforestation in Amazonia," contribution to *Change in the Amazon Basin*, *op. cit.*; Stephen G. Bunker, "Forces of Destruction in Amazonia," *Environment*, Vol. 22, No. 7, September 1980, p. 39.

[24] Adrian Cowell, *op. cit.* footnote 20.

while its forests, covering an area the size of West Germany, go up in smoke! Despite all the incentives and the money poured in (estimated at $12,000 per settler), no sustained output adequate to service investment in the region has arisen, and Amazonia produces only two percent of Brazil's gross domestic product.[25] Yet deforestation is accelerating, exponentially and unstoppably (unless road-building ceases), at a rate that will clear Rondônia by 1990 and the whole of Amazonia by 2000.[26]

But why was Amazonia chosen for settlement at all, when there are almost equally huge areas of undeveloped "campo" (prairies) far better suited for colonization, ranching and agriculture? The advantages of campo over rain forest were pointed out early on by many experts, including one of the World Bank's ecologists.[27] Did the forest have to be conquered out of *machismo*, for reasons of "conspicuous consumption"[28] or consumerism gone mad, to secure votes (as when Rondônia was created a state, title deeds being "bribes"), because forest represents "backwardness" (instead of an immense asset) in the Brazilian subconscious? Or—in mountaineering terms—simply "because it was there"? All these explanations have been given, and national motivation is certainly hard for outsiders to understand. A very few investors, a few multinationals, and the highway developers made money. Brazil as a whole has lost heavily; and as a result of this and other unfortunate political and financial decisions its external debt today is the largest of any country—$94.9 billion at the end of 1983.

A similar enormous forest colonization program is now under way in Indonesia, where political pressures are even greater than in Brazil. There is a diversity of peoples and religions, and there have been a number of separatist rebellions. In overcrowded Java one percent of farmers own 35 percent of agricultural land, and their large farms are less productive than smallholdings. Half of the smallholders have less than a half-hectare of land each, and half of all rural households own no land at all.[29] So millions of land-hungry but politically reliable Javanese are being "transmigrated," mainly to Sumatra, Kalimantan (Indonesian Borneo), Sulawesi, and West Irian. Four million are being settled in Kalimantan alone, at a cost of over $1,000 per hectare.

[25] Robert Skillings, "Economic Development of the Amazon—Opportunities and Constraints," contribution to *Change in the Amazon Basin*, *op. cit.*

[26] Philip M. Fearnside, "Deforestation in the Brazilian Amazon: How Fast is it Occurring?", *Interciencia*, Volume 7, No. 2, 1982, pp. 82–88.

[27] Goodland, *op. cit.*

[28] Thorstein Veblen, "Theory of the Leisured Class," 1899.

[29] Plumwood and Routley, *loc. cit.* footnote 19.

Despite the poverty of its soils (less than two percent are believed to be permanently cultivable), Kalimantan's forests are biologically unusually rich in species, and economically exceptionally valuable. Whereas those of Brazil have largely been burned, Kalimantan's are being sold (though correspondents report immense areas felled in advance of extraction, and left rotting). Transmigration and logging come under separate ministries; but the combined plan seems to be to clear these forests completely, using some of the logging profits to finance the Transmigration Program. Roads are laid out so as to penetrate remote areas and improve control over the indigenous inhabitants, lest they be disaffected—as well they may be, for most of the land is already owned under traditional law, largely ignored in the granting of concessions.

Concession agreements are for 20 years only, so the concessionaires, though frequently aware of the importance of conservation, have no option but to cut their lands as rapidly as possible, and no incentives to replant for someone else's benefit. Logging has been proceeding at the rate of over 800,000 hectares a year, while shifting cultivators following behind cut about 200,000 hectares of mostly previously logged and damaged or secondary forest. Extrapolating current clearing rates, there will be no trace of these forests left in 13 years.[30] As a result of the denuding of the Barito and Kahayan river catchment areas, floods in 1977 and 1979 destroyed the ricefields of 10,000 farmers, while a further 10,000 people were put out of work through the loss of forests from which they obtained ironwood for shingle making.[31] Visiting such areas it is hard to view without emotion the miles of devastated trees, of felled, broken and burned trunks, of branches, mud, and bark crisserossed with tractor trails—especially when one realizes that in most cases nothing of comparable value will grow again on the area. Such sights are reminiscent of photographs of Hiroshima, and Brazil and Indonesia might be regarded as waging the equivalent of thermonuclear war upon their own territories.

Major concessionaires have included Georgia Pacific and Weyerhauser (1.5 million acres). Weyerhauser (International Timber Corporation of Indonesia) had as its local partner an Indonesian company, owned by a foundation created by President Suharto to maintain the loyalty of 73 generals, who were given money by Weyerhauser with which to buy their shares and who shared 35

[30] Alan Grainger, Rain forest monitoring, Oxford University, personal communication.
[31] George Y. Adicondro, "The Jungles are Awakening," *Kogai*, No. 22, p. 61, Tokyo, 1979, quoted in Plumwood and Routley, *loc. cit.* footnote 19.

percent of the profits.[32] Some 80 concessionaires, including Weyerhauser, have reportedly now closed their Indonesian operations because of excessive demands made on them locally, including requirements to set up local timber-processing plants surplus to world market requirements.[33] Their place is being taken by local Chinese business interests, who already control over 75 percent of Indonesia's economy, and who will now decide the fate of Indonesia's forests.[34]

Indonesia's Transmigration Program is larger than Brazil's, and equally destructive of capital, of the environment, and of the societies involved. Despite these facts, because Indonesia has oil wealth and her forests are highly salable, it will continue longer, largely because "Javanization" of the outer islands is desired by the central government (whatever their local inhabitants may feel). Even so, the marks of failure are apparent: foreign debts now total $26.2 billion, and are growing; and the Program, like the lesser schemes of other rain forest countries, could not exist or continue without outside funding.

IV

If population growth and land-hunger form the top layer of the deforestation cake, and social conditions (under which suitable land is not available) form the second layer, then local political motivations and unwillingness to face realities form the third. Beneath this, the fourth layer of the cake is the ready availability of funding.

In 1976 lending to all developing countries totaled $75 billion. Since then the huge flows of money created by OPEC (rising oil prices), the printing of money (inflation), and savings have been lent by commercial banks (U.S. banks alone lent $300 billion) to governments, without adequate safeguards such as collectible collateral or the built-in supervision that characterizes ordinary lending.[35] As a result, today eight countries each owe more than $20 billion (including four of the largest rain forest countries), while

[32] Rachel Grossman and Lenny Siegel, "Weyerhauser in Indonesia," *Pacific Research*, Vol. 9, No. 7, 1977, p. 5, quoted in Plumwood & Routley, *op. cit.*

[33] Personal communication, 1983.

[34] There have been reports of timber royalties being diverted away from tribal landowners, and of other examples of corruption. Over $40 million (in the Sumitomo Bank, Singapore) is currently being claimed by the former employers of Hadji Achmad Thahir, an Indonesian official; and his widow has given "names at the very top of the Suharto Government whom she said were parties to the illegal payments . . . in support of her case that bribery is part of the system in Indonesia and that there was nothing untoward in her husband's dealings." See David Watts, "Indonesian Oil Bribes Case held in Camera," *The Times*, London, September 20, 1983.

[35] See, for example, Anthony Sampson, *The Money Lenders—Bankers in a Dangerous World*, London: Hodder & Stoughton, 1981.

Brazil ($94.9 billion) and Mexico ($91 billion) each owes more than the world total of a mere seven years ago; and the current world total has risen to around $400 billion.[36]

The result of this enormous expansion of credit and of investment was at first unprecedented economic growth, operating smoothly within the framework of free trade provided by the General Agreement on Tariffs and Trade. But unfortunately much of this growth has proved artificial. Instead of solving problems, it has worsened them, for reasons that lie not with the concept of aid, but with the method of lending. This is particularly apparent with the rain forest countries, which typically have non-democratic governments that are hard to change, poor or bad civil-rights records,[37] low per capita gross national product (GNP), frequently few cashable national assets—and high population growth rates and sometimes high populations (as shown in Table II above). Such countries have proved peculiarly vulnerable when given large sums of money. Even though the loans and investments themselves are "paved with good intentions," a clear sequence of causes and effects has frequently and cumulatively led to most undesired consequences:

—In general, loans have been made to governments, and major investments channelled through them, instead of to individuals, banks and businesses.

—This has strengthened governments, through whom the resulting funds flow.

—This has caused planning to become centralized, bureaucracies to burgeon, and an emphasis on grandiose schemes—power stations, dams, road networks, forest colonization: a disease that might be called "infrastructuritis."

—A wealthy elite is created around the government.

—This elite has little to spend its wealth on in a poor country—except land, which passes increasingly into fewer hands, and imported consumer durables such as cars, and technology. The elite becomes isolated from the rest of the country.

—Corruption grows.

—The import of technology is often tied in with the loan or investment agreements, and the use of this technology creates a second elite of technicians, including the armed forces and those involved in development projects.

—Unemployment grows, as land tenure and traditional rights and forms of employment change.

[36] Anonymous, "The Banker's Guide to LDC Debt," *The Banker*, London, January 1983, pp. 82–85.

[37] See Charles Humana, *World Human Rights Guide*, London: Hutchinson, 1983.

—To service the loans, or in agreement with their terms, the focus of economic activity moves away from self-sufficiency toward exporting (in 1950 Africa as a whole was self-sufficient in food; in 1978 it imported 12 million tonnes of cereals; in 1990 it will need 45 million tonnes, one third for Nigeria).

—As this happens, widespread long-term benefits for the many are replaced by short-term benefits for the few, while wealth is increasingly transferred from the poor to the rich, the gulf between whom widens.

—Forests are regarded as potential shelter for dissidents, and are cleared for security reasons.

—Due to bad planning (often based on imported models) adequate economic returns fail to materialize.

—Loan interest and repayments fall in arrears, and have to be rescheduled to avoid default.

—Environmental destruction increases, as capital resources such as forests and minerals are cashed in, in an effort to remain solvent.

Finally, if the nation is a democracy it will have changed its government and its policies long before this sequence runs its full course. Otherwise autocracy grows and spending on the armed forces increases. In any event, poverty and discontent grow, and dissidents, in their ignorance, may turn to the Eastern bloc for help.

All of this picture may not be true all of the time, but some of it is true much of the time. Unfortunately, no successful way of changing the sequence from outside has been proved, for withholding aid commonly leads to a threat either of default, or of Eastern bloc aid replacing Western. (If this last happens—officially, or unofficially to dissidents—then civil war of one sort or another is likely to break out.) The most promising steps could be taken by the banks and the International Monetary Fund, through decisions actively to support democratic institutions wherever they exist, and to encourage their development where they do not; and to try to change the form of loaning, so as to lend only against security, and at the broadest accessible level of individuals and small-scale projects, perhaps through specially set-up development banks, leaving the large-scale projects to fund themselves in their own proper time.

This would foster the growth of wealth from below. Until this happens the social causes of rain forest destruction will continue to worsen, and internal opposition to it will be stifled. The power-hunger, fear and greed that exist under repressive military governments are often the major threats to the environment; and internal movements concerned with conservation, reforestation and social

issues cannot develop so long as such autocratic regimes are supported by existing funding methods.

V

Rain forests are the only major asset of several poor tropical countries. How best can they use them to raise their living standards, without falling into the "development sequence" trap detailed above? The short answer is to get the full value, though how to do this may not be immediately apparent.

Ecologists describe Mature-phase rain forest as having several (often ill-defined) "strata," the most obvious being the top layer of tall trees whose crowns form a continuous canopy, usually between 40–55 meters above the ground. Protruding through this are occasionally even taller trees, called emergents; while below it are layers of smaller trees which can tolerate shade, whose crowns pack together at say 25; 15, and 6 meters. Some of these may be saplings waiting to push through to the upper layers; but most are probably true understory trees that never get any taller. A large rain forest may contain as many as 1,800–2,500 species of trees (Sarawak and Brunei)[38] as against the mere 7–15 in a temperate forest; there may be as many as 400 larger kinds in a single hectare, many of them only occurring once.

Below them there is sometimes a layer of shrubs, and below that one of herbs, depending upon how much light penetrates downwards. Scrambling through and over all these layers are numerous climbing plants, sometimes hundreds of feet long; while upon the branches of the trees, and even upon their twigs and leaves, sit yet smaller plants—epiphytes and epiphylls: orchids and bromeliads, algae, mosses, liverworts, ferns, horsetails, selaginellas and lycopodiums. Animal life of every kind—multitudes of mammals, birds, reptiles, amphibians, fishes, mollusks, worms, spiders, insects and other invertebrate creatures—live in, on and among this vegetation, and are interdependent with it, and this complexity continues below ground level. This huge concatenation of species has evolved together to take advantage of every available input of the environment, to utilize carbon dioxide and catch sunbeams and water, water vapor and minerals at a primitive level; and at increasingly sophisticated levels, by means of an elaboration of chemistry and of behavior that is unmatched anywhere else, to defend and enlarge its roles. Building-phase forest, or plantations of uniform species,

[38] Whitmore, *op. cit.* footnote 11.

have far less complexity, and in consequence less ability to use and control the environment.

It is obvious that we understand and exploit but a microscopic fraction of the potential of all these riches—the treasure trove of genetic material that is irreplaceably lost when rain forest is destroyed, for almost every area has something unique. Several million rain forest species, mainly of invertebrates, have not even been seen or described by scientists. Fewer than 200 species of edible plant are used commercially, while 16 provide 90 percent of the world's food.[39] Yet over 80,000 are already known, mostly from rain forests, and none of them yet cultivated. And beside food plants and animals, the forests contain medicinal species, species with varied industrial uses, species used in making clothing, cosmetics, and for hundreds of other purposes. It will be many years, possibly centuries, before we can do justice to all this material—if it survives.[40]

Meanwhile, what we are selling is not the wealth of the forest, or its environmental benefits, but just timber. Only 15–20 tropical woods are of international market importance, and to extract these it is worth making roads into the forest, or even lifting out by helicopter. Even in the rare cases where we have expert foresters who can recognize in the field all 400 different kinds of large tree, at today's prices it is uneconomic to sort out any but the most valuable into end-use classes. The very plethora of varieties is an embarrassment when demand in the timber trade is for standard raw materials with which to make uniform products at the cheapest possible price. Clearly, natural rain forests are intrinsically not well suited for industrial use—for sawmilling, plywood, paper and pulp production, or making woodbased panels; trees grown in monocultural (single species) plantations are far better, being uniform in size and quality. Approximate uniformity is sometimes achieved by chipping all the trees of the forest, and compressing with adhesives to make artificial board. Mostly it is cheaper to ignore the majority, even though many are excellent woods used locally, and have potential for development and export. In a few years' time, as supplies of tropical timbers fall below demand, their monetary value

[39] S.G. Harrison, G.B. Masefield, and Michael Wallis, *The Oxford Book of Food Plants*, Oxford: Oxford University Press, 1975.

[40] For discussions of this issue see Professor J. Heslop-Harrison, "Genetic Resource Conservation: The End and the Means," *Journal of the Royal Society of Arts*, London, February 1974, pp. 157–169; Ghillean Prance, "The Increased Importance of Ethnobotany and Underexploited Plants in a Changing Amazon," contribution to *Change in the Amazon Basin*, *op. cit.* footnote 22; Ira Rubinoff, "Tropical Forests: Can we afford not to give them a Future?", *The Ecologist*, Vol. 12, No. 6, 1982, pp. 253–258; Norman Myers, *The Sinking Ark*, Oxford: Pergamon Press, 1979.

will rise, and they will be harvested and processed with care; currently they are too cheap often even to leave growing when the forest is logged.

Frequently 90–98 percent of trees are left unused when an area of rain forest is logged. If exploited non-mechanically, a logged forest may appear scarcely affected, but with mechanization felling is more destructive, and tractor extraction packs and disturbs the soil so that natural regeneration is reduced. Where ten percent of the trees are extracted, around 55 percent are usually irreparably damaged, and 35 percent left standing.[41] Of a total rain forest standing volume of 200–350 cubic meters of timber per hectare (up to 500 is known) only between 5–30 cubic meters are generally used in the lumber industry, three to six cubic meters for export.

In Southeast Asia extensive forests exist of trees of the family *Dipterocarpaceae*, which have similar wood, making these forests commercially more valuable than the generally more mixed forests of Africa or Latin America. Because Dipterocarps set seed simultaneously every few years, it is possible to fell such forests at the right time, and they will regrow little harmed. But although this is widely known, in the rush for quick cash it is ignored, and throughout the Philippines, Malaysia, and now Indonesia these forests are being substantially logged out of existence.

During the period 1950–1980 Nigeria became an importer instead of an exporter of timber, and the forests of Ghana, Thailand and several other countries were depleted to the point where they could no longer supply even local demand (today Thailand imports $44 million of wood per annum); in Central America, between 1961 and 1978, 39 percent of the forests were felled and the land converted to cattle ranching.[42] In the Philippines, log exports declined after 1976 to one quarter of the previous level, after the almost complete removal of all accessible lowland forests—with resultant annual severe floods, landslides and loss of life. In Brazil, felling for fuel to stoke iron smelters, along with other activity, has reduced the remarkable and once extensive Atlantic rain forests (home of unique primates) to a few tiny patches.[43] Along the forest

[41] P.F. Burgess, "Effect of Logging on Hill Dipterocarp Forest," *Malayan Nat. Journal*, Vol. 24, 1971, pp. 231–70, cited in Whitmore, *op. cit.* footnote 11.

[42] While Amazonian beef is sold mostly for home consumption, Central American is largely exported to the United States, where production costs are four times as great, for processing into hamburgers and frankfurters. Myers proposes that this trade has arisen because, faced by steep domestic beef price rises, the U.S. government has repeatedly increased beef imports as a simple means of reducing the retail price index by one point—in so doing unwittingly financing large-scale deforestation. Norman Myers, "The Hamburger Connection: How Central America's Forests Become North America's Hamburgers," *Ambio*, Vol. 10, No. 1, 1981, pp. 3–8.

[43] John Hatton, University College, London—personal communication, May 1985.

margins of Central and East Africa an exponential decline in firewood yields is forcing the growing populations to eat uncooked food. In Nepal "landslides and catastrophic floods are becoming annual disasters."[44]

Starting in the 1950s, commercial logging (sponsored by the Indian government) reduced forest cover in the Himalayan foothills by 40 percent and has led to irrigation works in Uttar Pradesh being choked (six billion tonnes of topsoil are washed away each year), while in Bengal and Bangladesh thousands have died from floods, and huge areas of ricefields have been destroyed (in protest, the Chipko movement has arisen, whose members hug trees to prevent them being felled).[45] And deforestation is still increasing—both in countries like the above where there is population pressure, and in sparsely peopled nations such as Papua New Guinea, Solomon Islands, Zaire and Gabon, in all of which large-scale logging contracts have been awarded as a part of export-oriented development programs (only in the Solomons is reforestation on a commensurate scale).

VI

The FAO has summarized the consumption of tropical hardwoods for all uses (including fuel) during the period from 1950 to 1980, and made projections of estimated consumption in 2000, with the results shown below.

TABLE III

CONSUMPTION OF TROPICAL TIMBERS IN 1950 AND 1980 AND ESTIMATED CONSUMPTION IN 2000
(in millions of cubic meters)

Countries	1950	1980	Increase	2000	Increase
Japan	1.5	35	2233%	48	37.1%
United States	0.8	10	1150%	20	100.0%
Europe	1.9	21	1005%	35	66.6%
Other importers	1.0	13	1200%	23	76.9%
Subtotal	5.2	79	1419%	126	59.5%
Producer countries	21.0	66	214%	185	180.0%
Total	26.2	145	453%	311	114.0%

SOURCE: FAO, "Agriculture: Toward 2000," Rome, 1980.

[44] Barney, *op. cit.* footnote 3, p. 321.
[45] S K. Chauhan, "Tree Huggers Save Forests," *Development Forum*, Volume 6, No. 8, 1978, p. 6.

These figures show that during the 30 years between 1950 and 1980, consumption of tropical hardwoods rose far above the increase in living standards of the importing countries. In the industrial nations, consumption was over twice that of all the tropical producer nations combined, despite the producers' far greater populations. The reason was the cheapness of tropical timbers compared with other materials, combined with their ready availability due to the policies of the producers, which often amounted to deliberate (or at best uncontrolled) asset-stripping. Between 1980 and 2000, growth in consumption is still estimated far to exceed economic growth, though to a lesser degree.

If present trends continue, by 2000 world timber stocks per capita will have fallen from 142 cubic meters to 114 cubic meters (i.e., by 28 cubic meters) in developed countries; and from 57 cubic meters to 21 cubic meters (by 36 cubic meters) in less-developed countries. There will be severe shortages of every kind of forest product, prices will be accelerating upward, and the sources of tropical timbers will have changed as present suppliers are depleted. The prospect is shown below:

TABLE IV

SOURCES OF TROPICAL TIMBERS IN 1950, 1980 AND 2000
(in millions of cubic meters)

Source Region	1950	% of Exports	1980	% of Exports	2000	% of Exports
Africa	4.7	32%	20	60%	35	29%
Latin America	15.5	5%	32	13%	118	24%
Asia and Pacific	14.3	14%	93	70%	158	80%
Total	34.5	17%	145	47.6%	311	44.3%

source: FAO, "Agriculture Towards 2000," Rome, 1980.

Globally, the World Bank estimates that an extra 500–600 million cubic meters per annum of industrial woods will be needed in 2000, plus an extra 200–900 million cubic meters of fuel woods. They predict that by then this extra supply will only be obtainable from the remoter parts of Amazonia and Siberia, from the utilization of lower quality North American hardwoods, and from plantations of faster growing tropical trees, if they are created in time. Reforestation for industrial needs will have to be doubled, and for fuel woods increased five times, if essential needs are to be met. The cost of such a program would be between $1.5 to $2.4 billion per annum, of which the World Bank proposed to supply 25–30 per-

cent.[46] FAO projections of needs are even more pessimistic, as shown below:

TABLE V

WORLD DEMAND FOR FOREST PRODUCTS IN 1980 AND 2000
(in millions of cubic meters)

Use Countries	Industrial Wood		Fuel Wood		Totals	
	1980	2000	1980	2000	1980	2000
Developed[1]	1100	1622	150	<80	1250	1702
Developing[2]	250	463	1000	1200[3] (1900 if available)	1250	1663
Total	1350	2085	1150	1280 (1980)	2500	3365 (4065)

Major categories of industrial wood are:

	1980	2000
Sawn wood	455–470	570–652
Woodbased panels	109–125	169–351
Paper (millions of tons)	180–182	357–445

[1] 30% of world population in 1980
[2] 70% of world population in 1980
[3] 10–20% for charcoal
NOTE: Figures include both temperate and tropical products.
SOURCE: F.A.O., "Agriculture: Towards 2000," Rome, 1980.

FAO concludes that: "Accepting that the figures constitute only a rough conservative estimate of investment needs, their magnitude is striking." To meet the forecast demand, they have calculated that investments of between $1,000 to $1,240 billion will be required to keep the world adequately supplied with forest products (excluding fuelwood) between now and 2000.

Between $340 and $440 billion of this total ($17 to $22 billion per annum) will be needed by the developing countries, mostly tropical. Between $2.3 and $3.8 billion per annum of this will be for expanding capital industrial plant, and $1.7 billion per annum for replacing existing plant, while $0.8 to $0.9 billion will be for logging and primary transport equipment. But by far the greater part of the sum for developing countries, $12 to $16 billion, is needed for plantations to replace wood being cut.

In the short run these would reduce pressure on rain forests, and

[46] John S. Spears, "The World Bank's Forestry Lending Program," Geneva: U.N. Conference on Trade and Development, 1980.

in the longer term they could take their place as the main source of supply for industrial and fuel wood. In 1980, plantations of tropical hardwoods for use as sawwood totaled 43,490 square kilometers, and there were a further 27,180 square kilometers of softwoods for chipping and veneer, as well as 44,440 square kilometers planted to provide fuel. As a first crop of the fastest-growing species may produce up to ten times the *usable* volume of natural rain forest (20 cubic meters of wood per hectare per annum as against two to six cubic meters), so by 2000 these plantations in theory could produce some 230 million out of the FAO-projected total world demand of 3,365 million cubic meters of tropical timber. To satisfy *all* of this demand we would need to start increasing the area of plantations by 15 times immediately, to some 1,700,000 square kilometers—nearly 11 times the rain forest area currently being cleared annually. The total cost would be between $170 and $272 billion ($10 to $16 billion a year, over 17 years).

As world demand outstrips supply, forest product prices can be expected to rise steeply, until eventually they reach the cost of replacement. By 1990 there should be strong incentives to invest in fast-growing trees; while after about 2010 even plantations of slower-growing hardwoods should be attractive. Already some planting is being done in anticipation of these forthcoming shortages, the largest scale example being Daniel K. Ludwig's billion-dollar Jari scheme near the mouth of the Amazon, where it was hoped to grow *Gmelina arborea* and *Pinus caribaea* trees on very short rotations of 7–15 years.[47] The notion that industrial forest plantation methods like those of the United States or Scandinavia can be transferred to the tropics has been disproved again and again, and very expensively, during the last century, and no more so than in this case. Of 15,000 square kilometers purchased, over 1,000 were planted after felling and burning the rain forest. A 500-tonnes-a-day pulp factory was constructed in Japan, and towed to the site; but the trees failed to grow as expected, and today the scheme is bankrupt, its $180 million of debts assumed by the state-controlled Banco do Brasil.

Plantations require heavy investment and skilled management, and are seldom yet commercially viable when shorn of tax advantages—while natural forests appear to be free. Plantations on the

[47] A. Greaves, "*Gmelina*—Large Scale Planting, Jarilandia, Amazon Basin," *Commonwealth Forestry Review*, Volume 58, No. 4, 1979, pp. 267–69; Antonio Machado, "A Encruzilhada do Jari," *Veja*, December 3, 1980, pp. 68–79; Hamlet Pauletti, "The Forest Closes in on Millionaire Ludwig," *WorldPaper*, January 1981, p. 9; Bernardo Kucinski, "Brazil's Amazonian Dream Ends Up as a Nightmare," *The Guardian*, London, January 13, 1982.

largest scale are needed, but the danger is that the magnitude of the sums required to create them will accelerate rain forest destruction—in which case the cure will be worse than the disease. If existing wastelands were reclaimed, however, and existing damaged or cleared forest replanted, adequate lands would be immediately available; and if tree planting was combined with agricultural settlement, costs and labor problems could be reduced. Such agroforestry projects are still in their infancy, but have been successful in several countries.[48] At their best they follow closely the models established by tribal peoples, using agriculture and tree plantations as parts of a Building phase that leads on to Mature-phase forest, which occupies at all times a majority of the land used.

VII

One central fact emerges from this survey: that tropical rain forests are considered disposable; that they and their products are cashed in wherever possible, or destroyed and converted for quick profits—whatever the long-term consequences. This situation has arisen historically for a number of reasons:

1. Governments and foresters are largely non-commercial in outlook: they operate their forests as a sort of charity, offering agriculture and ranching with their lands, and providing the multi-billion-dollar high-profit-making timber and forest products industries with their raw materials, all at far below replacement costs. Farmers, on the other hand, operating on short rotations, know their costs and price accordingly.

2. As a result of this, the true cost of producing tropical timbers is unknown, except in a very few cases such as plantation teak. The cost of producing rain forests is even less known—they are "grown by God." The value of their environmental benefits can be gauged only by the cost of replacing them, which is enormous; while that of their contained species and materials is unguessable, because we have hardly begun to exploit them.

3. The existence of huge areas of natural rain forest for the whole of past history has meant that the available supply of tropical timbers and forest produce has always greatly exceeded the demand.

4. Because of this historical oversupply, the price of tropical trees *in the forest* is negligible—heavily forested land can be bought for

[48] J. Dubois, "Aspects of Agroforestry Systems used in Mayombe and Lower Congo (Zaire)," and other papers in *Workshop Agro-Forestry Systems in Latin America*, Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica, 1979; International Labour Office, "Appropriate Technology in Philippine Forestry," Geneva, 1977.

$25 to $100 per hectare throughout the tropics. Timber prices are based mainly on felling and extraction costs, with a markup dependent on current demand. Wherever supply constraints exist, however, as with certain furniture woods, prices are consistently high.

5. Because they are relatively so cheap—whatever the consumer countries say at the United Nations Conference on Trade and Development (UNCTAD), or timber trade representatives say in the press—world demand for tropical timbers has grown faster than that for any other major raw material.

6. Because of these low prices, waste is on a scale inconceivable in a world whose resources are finite and shrinking—and in some countries it has become advantageous to destroy forest, convert to agriculture or ranching for as little as three to five years, and then abandon the derelict land.

Despite wide awareness of the gravity of this situation, and of the speed and extent of tropical deforestation, no coherent plan for tackling the problem has been adopted. Partly this stems from despair at the seemingly unrealizable sums needed, and partly from the economic weakness and disunity of the rain forest nations. Between 1984 and 2000 some $700 to $2,790 billion for human settlement; another $240 to $320 billion for reforestation and industrial wood plantations; between $96 and $128 billion for industrial plant and equipment, and further unestimated sums for fuelwood plantations, would be needed: sums totaling between $1,200 and $3,500 billion over a 16-year period ($75 to $219 billion per year) *at a conservative estimate.*

Could we contemplate multiplying today's debt burden by anything up to six or seven times, unsecured, and without clear prospects of adequate returns? Yet without such funding, already dangerous conditions for vast landscapes and huge populations will slide further toward catastrophe; irreparable damage will be done, costs will escalate, and eventual costs will be incomparably greater.

Though both FAO and the World Bank, the two largest international organizations currently involved in reforestation and agricultural settlement, have unrivalled expertise, forestry is very much a junior partner within both organizations—undoubtedly because, both globally and hectare for hectare, the financial returns from agriculture are currently so much greater. In their development planning, agricultural uses are almost always given preference over forestry, where there is a choice between them—despite the often greater long-term benefits of forestry.

Between 1968 and 1980 the World Bank financed 32 major

reforestation projects in 27 countries (not all tropical), for a total of $1,154,900. During the same period it spent very much greater sums on projects destructive of forests—roads, hydroelectric schemes, pulp mills, and much else. Since 1980 its lending for forestry has increased from 0.5 percent to six percent of its total agricultural [sic] spending, and it has proposed yet further increases, to be jointly funded by the countries receiving the loans. The bank lends at commercial rates of interest, and the economic rate of return on these 32 projects was 11–22 percent, while the cost per hectare varied from $280 in the Philippines to $3,500 in Liberia.[49]

Each World Bank project is a model of careful planning and implementation. Yet increasingly there are fears that the availability of its loans (and those from other sources) may actually encourage deforestation in poor countries: that they can gain in the short term twice over, first by selling their forests, and then by getting loans to reforest and repair the environmental damage—to pay for which they cut more forest; while the banks and lending countries acquire interest payments, export orders, and political and economic power. Indeed, everyone gains except the environment, which is ruined at an accelerating pace.

Clearly the sums available to FAO and the World Bank do not total more than a minuscule proportion of what is needed. And it is hard to imagine the immense funding required being made available to either organization by member governments, who are already critical of the size of their budgets and the way they are spent.

Nor do the efforts of the various conservation bodies offer much hope. Despite the financial stringencies that these organizations habitually suffer, they do outstanding work by fielding research groups to list endangered species and study their habitat requirements, and in securing the creation of national parks and forest reserves, and perhaps above all by arousing public awareness—though not much where this is most needed, in the developing countries themselves.

In 1980 the largest of these, the International Union for the Conservation of Nature and Natural Resources and its sister fund-raising organization, the World Wildlife Fund, together with the United Nations Environment Program, launched the "World Conservation Strategy" in an ambitious attempt to provide guidelines

[49] John S. Spears, "Overcoming Constraints to Increased Investment in Forestry," paper presented at Eleventh Commonwealth Forestry Conference, Trinidad, 1980; John S. Spears, "The World Bank's Forestry Lending Program," *loc. cit.*

for governments.[50] This proposed three principal objectives: "Maintenance of essential ecological processes; preservation of genetic diversity; ensuring that the use of species and of ecosystems is sustainable" (an important goal being the preservation inviolate of ten percent of tropical rain forests). Unfortunately they spoiled the clarity of this message by an additional aim—"to deliver conservation-based development where it is most needed, notably the rural areas of developing countries." This has proved to be a piece of "double-think" in the context of actual development practices in the Third World, where, because of the competitive factor and the absence usually of a powerful local conservation lobby, good intentions are frequently overlooked where there is a profit to be made. As a result, even governments who have adopted the Strategy have in practice allowed logging within reserves, and have proved unable to protect reserves when all around is poverty, hunger, overcrowding—or greed.

If this is so today, how much more so will it be in 30 years' time, when around the parks the trees have all gone and the lands are waste? The approach of conservation therefore is but a comforting delusion, which at best buys time, and at worst distracts attention from the real issues by asserting that something is going to be saved. For parks and reserves will *not* be saved unless the lands around them are saved also; and this will only happen when the economic, social, educational and political circumstances causing environmental destruction are changed.

In 1985 UNCTAD concluded an ICA (International Commodity Agreement) on tropical timbers, to last for five years; though it has yet to be ratified by member governments, who include both producer and consumer countries.[51] Work toward it, under the chairmanship of Japan (for which tropical timber imports rank second only after petroleum), has been proceeding since 1976.[52] During this period, important work has been done in clarifying detailed aspects of the international timber trade—in categorizing the diversity of tropical trees and other forest products, and in devising information, bargaining, and enforcement procedures.

Eventually it is hoped that funds will be available to members out of a proposed Common Fund, designed to cover *all* commodities for which there are ICAs (cocoa, coffee, sugar, tin, rubber, wheat,

[50] IUCN, "World Conservation Strategy," Gland, 1980.
[51] UNCTAD, "International Tropical Timber Agreement, 1983," TD/Timber/11, Geneva: United Nations, 1983.
[52] UNCTAD, "Preparatory Meetings on Tropical Timber," TD/Timber Series, Geneva: United Nations, 1976–1983.

olive oil, and jute). The proposed aggregate capital of this Fund is three billion dollars---one third as paid-up risk capital subscribed by members, two thirds as loans carrying interest charges; and with a further three billion dollars on call from participating governments in the same proportions, backed by the collateral of the relevant commodities. The First Account of this Common Fund is intended to provide buffering finance for members undergoing difficulties (chiefly stock spoilage); while the Second Account is intended to finance tropical timber projects, including reforestation, as well as jute, olive oil, wheat, and natural rubber producers, whose commodity is less subject to spoiling if unsold. So far the United States has withheld support; the direct capital sought has been reduced to $450 million, and $325 million has been pledged.[53] In any case, the idea of this Common Fund has now been under discussion for nearly ten years. It is hardly an early possibility; and even if it existed, tropical timber interests could claim but a fraction of its available assets because of the number of competing commodities.

Although the International Tropical Timber Organization established by the 1983 UNCTAD agreement might conceivably develop one day into a "world forum" on forestry, for the present the agreement is severely limited—to cooperation in research and development in three fields: on improving management and reforestation techniques; on a monitoring system "to make the market more responsive to the needs of users"; and on increasing domestic processing by producers. The main purpose of these many years of meetings was to secure an agreement on regulating trade; that so little has been achieved is a mark of the extreme disparity of position of the producers and consumers, as is especially shown in the uncertainty of the tropical timber market, which has been cleverly manipulated by the main buyers (especially Japan) to keep prices low.

VIII

If the prospects for effective international action through existing agencies are thus extremely limited, and those for fruitful cooperation between producers and consumers virtually nil, is there some other way to meet the problems of protecting and replenishing the tropical forest environment in general, and of its gene stocks and special habitats in particular, while at the same time permitting the

[53] Personal communications with UNCTAD and UN staff.

forest countries to earn an adequate and proper return for their products?

In my view the most constructive and workable possibility would be through the formation of an Organization of Timber-Exporting Countries. At the XI Commonwealth Forestry Conference in Trinidad in 1980, and subsequently, I have put forward the idea of such an OTEC. Since then I have received many comments, ranging from strong advocacy to hostile criticism, but all helpful in clarifying the idea.[34] The name OTEC has aroused some distaste, especially in the United States and Great Britain, where it stirs negative feelings engendered by OPEC. However, OPEC did succeed in focusing world attention on the problem of renewable and non-renewable resources, and it remains the outstanding example of successful Third World cooperation. A neutral name (such as UTFN—Union of Tropical Forest Nations; or WFO—World Forest Organization) could be given to an actual organization; meanwhile "OTEC" is already widely used for discussion, so I shall continue with it now.

At an early stage UNCTAD considered cartelizing tropical timbers, and rejected the idea by consensus. Members feared that if prices were raised artificially there would be widespread development of substitute materials, and that the whole market would collapse; they assumed that a true live market relationship operates between demand and supply for tropical timbers, and that a cartel would jeopardize this; and they doubted whether cohesion of purpose could be achieved. It is worth considering these fears in detail.

Substitution. All the substitutes for tropical timbers are either other species from other countries (the various "mahoganies," etc.), or highly energy-intensive in production. For construction, steel and concrete are the main substitutes; for furniture, aluminum and plastics—and plastics are largely derived from petroleum, coal or wood, or use wood particles as a filler (as first petroleum and then coal supplies diminish, wood must become their main raw material source, and silvichemistry will replace petrochemistry). Demand for hardwoods is predicted to expand greatly, and supplies are diminishing. Therefore a large enough group of tropical forest nations should be able to exert considerable leverage on the prices and supplies of substitutes as well as on the hardwoods themselves.

Concerning tropical softwoods the position is less certain, for

[34] Nicholas Guppy, "How Forest Conservation Could become a Profitable Operation," (1980) and "Why OTEC?" (1981), reports distributed by the Threshold Foundation, London; Nicholas Guppy, "Proposals for an Organisation of Timber Exporting Countries (OTEC)," *The Malaysian Forester*, Vol. 46, No. 2, 1983, pp. 1–19; Nicholas Guppy, "The Case for an Organisation of Timber Exporting Countries (OTEC)," in S.L. Sutton, T.C. Whitmore and A.C. Chadwick, Eds., *Tropical Rain Forest: Ecology and Management*, Oxford: Blackwell Scientific Publications, 1983.

atmospheric pollution is reportedly killing large tracts of temperate softwood forests in the Soviet Union, Canada, Germany and Scandinavia.[55] How long such dead or dying trees would remain usable if unharvested is uncertain, and during this period prices for tropical softwoods would have to remain low of necessity. But in the longer term all temperate-zone softwood producing nations would surely wish to take advantage of higher prices created by a primarily hardwood cartel, and might wish to join.

Market Forces. Mature-phase rain forest trees take 80–200 years to develop fully, and rain forests themselves 400 years or more. There can thus be no true live market relationship between the demand and supply for either; and there is a strong legitimate case for removing both of them from the unrestrained action of market forces.[56] Some sort of "handicap" system is needed to place natural forests, for which no growing costs have been incurred, economically on a par with alternative uses for their land, especially when these can be shown to be of only short-term advantage—as has been abundantly demonstrated with rain forest. Such a handicap would need to be imposed artificially, through international action by means of a cartel or other structure.

It has been suggested that such action should first develop on a regional cooperative basis, through ASEAN (Association of Southeast Asian Nations), OAU (Organization of African Unity), or the Amazon Treaty countries. Yet already cooperation within ASEAN has included timber marketing and pricing: nonetheless the forests of Thailand have virtually disappeared, while those of the Philippines, Malaysia (which is deforesting even more drastically than Indonesia, though with less publicity) and Indonesia are following fast. This situation will not change until the major rain forest countries *of all three regions* simultaneously unite in a single organization.

Lack of Cohesion. Perhaps even more significant than the sums required to solve the world's rain forest problems has been the lack of success of existing forums (such as UNCTAD, ASEAN, OAU) in getting conflicting factions to agree. A body representing both consumers and producers might concur in an ideal world, but is hard to make work in this one, where each country must be expected to pursue the course most to its advantage. But would

[55] Boris Komarov, *The Destruction of Nature in the Soviet Union*, London: Pluto Press, 1978; Brian Jackman, "Ten Billion Dying Trees," *The Sunday Times*, London, April 4, 1985.

[56] Fast growing building phase trees are irrelevant in this discussion, as growing them is a form of agriculture; so are FAO or other official figures of "production" from tropical forests—for they actually refer to *harvesting*, and from a shrinking supply base (which, against an ascending demand curve, is a classic formula for disaster).

such conflicts prevail in a purely producers' organization with a single purpose?

It has been said that because of their weak economies and lack of political will, tropical forest countries would be unable to maintain cartel prices in the face of trade retaliation, or sustain agreements on sharing costs and benefits; and that the larger forest countries within the cartel would object to cutting less than their annual hardwood increment. Much the same sort of things were said about OPEC originally. But OPEC survived because the level of benefits it produced were so enormous as to ensure adequate cohesion even in troubled times.

It would be unrealistic to suppose that governments, corporations and individuals would readily give up the "license to print money" that rain forest destruction has become, unless they could obtain greater immediate short-term financial benefits from preserving than from destroying it. A timber cartel would have to achieve these by raising timber prices substantially—at least into line with currently cheaper alternatives, viewed globally. The experience of OPEC suggests that, once prices were raised, though countries outside a timber cartel might accelerate cutting and sell at lower prices, non-cartel prices would lag only slightly behind those of the cartel.

The Reforestation Fund proposed by UNCTAD, and the reforestation projects funded by the World Bank and other agencies, small though they are compared with what is needed, all represent hidden extra payments, above market prices (and mainly out of consumer nations' taxes), for rain forests and their products. But they do not strike at the heart of the problem, which is the low *market* value of these forests and products compared with other land uses and substitutes (many of whose low prices depend on the cheapness of their forest-derived ingredients). The object of an OTEC would be to redress this imbalance openly by increasing massively the asset worth of tropical forests and of the countries in which they occur, and to realize this enhanced value commercially.

This could be achieved by various forms of taxation, such as a Reforestation Tax,[57] or an Export Tax coupled with an Environmental Degradation Tax,[58] depending upon each country's internal circumstances and trade agreements. A scheme which preserves the operation of market forces more flexibly than taxation is that of Herman E. Daly.[59] With this, "Depletion Quotas" of a resource (in this case giving the right to fell a particular volume or area of

[57] Spears, paper cited in footnote 49.
[58] Goppy, final article cited in footnote 54.
[59] Herman E. Daly, *Steady-State Economics*, San Francisco: W.H. Freeman & Co., 1977, pp. 61–68.

timber, whether publicly or privately owned or under concession) are auctioned by governments. Reserve prices can be calculated and set which leave an incentive to buy, and can be raised progressively as the market adjusts upwards. So long as the reserve is not set too close to the market equilibrium point (at which there is no incentive to buy), the government thus captures what economists call the "Price Scarcity Rent" of the resource. Psychologically also, the purchaser of a quota knows what he is buying, whereas the payer of a tax does not.

Requirements of an OTEC would include commitments:

1. To reduce the exploitation of forest lands (especially natural forest) by means of legislation.

2. To increase the price of forest products by means of taxes, or by setting a reserve price on each harvesting quota auctioned.

3. To use the extra revenues thus created in agreed ways, and to pay a portion of these revenues into a common fund, whose main function would be to provide buffering or other finance when needed by members, and which could be used also to exert leverage on members not meeting their obligations.

4. To coordinate these actions in harmony with other members.

5. To agree on a timetable for the above.

Ten countries (Table I) contain 75 percent of all tropical forests; and a somewhat different ten countries export 92 percent by value of all tropical forest produce. Combining these two lists, we find that 17 countries represent over 92 percent of the world export trade in tropical timbers by value, over 92 percent by volume, and over 90 percent of the remaining tropical forests by area. If the decision-makers of these 17 countries could be persuaded to cooperate, an effective OTEC could certainly be created. These countries are (in alphabetical order): Bolivia, Brazil, Burma, Cameroon, Colombia, Gabon, India, Indonesia, Ivory Coast, Liberia, Malaysia, Papua New Guinea, Peru, Philippines, Venezuela, and Zaïre. (For comparison, OPEC consists of 13 nations, of which Gabon, Indonesia and Venezuela are in this list.)

Just what export (and local) price increases should be sought would of course depend on the market situation and the current comparative prices of substitutes for tropical woods. The object should be to generate increased income for the producing countries, to reduce waste and regulate production levels, and at the same time to avoid price levels that would upset the world economy or lead to massive and uneconomic efforts to develop substitutes. And the surplus over present income should be used by the producing

countries, at least in part, for systematic reforestation and conservation measures.

For illustrative purposes, as OTEC got under way, export price increases achieved by it could generate revenue surpluses as follows: for member countries a 50-percent increase would generate a surplus of approximately $2.7 billion per annum, with an inflationary push of 0.13 percent on world export prices, and a push of 0.03 percent on world GNP; a 300-percent increase would generate a revenue increase of some $16.3 billion per annum, with an inflationary push to world export prices of 0.8 percent, and a push to world GNP of 0.16 percent (excluding possible multiplier effects in both cases). If a 300-percent increase was accompanied by a 25-percent reduction in harvesting *by volume*, the surplus export revenue derived would drop to $12.2 billion per annum for member countries; while if the reduction was by *area*, and waste was diminished substantially, there need be no loss of revenue.

But could the market support such price increases? And would the public tolerate them? Outside the tropical forest countries there would be many beneficiaries from an increased asset value of forests and timber stocks, including non-tropical countries like the United States, which produces both hardwoods and softwoods in great quantity. Timber companies would benefit, so long as the price increases were firmly maintained; because of the multitude of ways in which timber is used, the added costs would be spread more widely and thinly than were oil price rises, and might in part be absorbed. Based upon forecasts of timber consumption (Table III), initially Japan would bear 38 percent of such price rises; Europe, 27 percent; the United States, 16 percent; and all other importers combined, 19 percent—*considering export price rises alone*. Japan might therefore be expected to oppose an OTEC most strongly, and as it is the main importer of Indonesian oil and of Indonesian timber (90 percent of plywoods used in the United States come from Japan and are made from mainly Indonesian and Malaysian Dipterocarp woods), Japan, if it so wished, would be in a position to exert pressure upon Indonesia not to join. Yet there is no doubt about Japan's genuine concern at the depletion of tropical forests, as is shown by its offer of $100 million through ASEAN for the setting up of a regional forest research center.

Bearing all considerations in mind, the price rises mentioned are small compared with those achieved by OPEC (some 900 percent over nine years)—in the case of OPEC it was the very magnitude of its increases that ensured cohesion and success. OPEC's huge cash surpluses accrued to relatively few nations, mostly with low popu-

lations. The tropical forest countries are more numerous, with far greater populations in aggregate, and the resulting benefits would be widespread. As their economies expanded, the percentage of the price rises borne by the developed nations would fall dramatically, as can be seen from Table III, until eventually 60 percent of these revenues would derive from the producer nations themselves. Surely the extra initial costs would be a small price to pay if the surpluses generated were used to solve the current human and economic troubles of these nations, and avert the yet greater and more costly environmental and human problems that today seem inexorably approaching.

Even though the figures mentioned refer only to export prices, and to the first steps in getting tropical forest destruction under control, they greatly exceed all sums at present available through existing organizations. And they would increase as local price rises joined those of exports. As prices rise, we can anticipate that fuller utilization of tropical trees will be made—indeed, theoretically, if waste is eliminated, the area logged can be reduced by 50–90 percent with no loss in volume output. And other similar contractions of scale throughout this toppling edifice of causes and effects can be anticipated, which will rapidly reduce the magnitude, complexity and costliness of rain forest problems to manageable proportions—once revaluation is applied. For while money appears the immediate issue, lack of it has not produced these problems. The deepest layer of the cake is what Oscar Wilde would have called Cynicism—knowing the price of everything and the value of nothing. When price and value are not identical, the world loses shape.

The responsibilities of an OTEC would be far greater than those of a conventional cartel. Besides obligations to maintain and enhance the financial value of a major national asset of each member state, and to secure adequate returns from it, it should concern itself with ensuring that member states protect the forest environment in general and gene stocks and special habitats in particular, create plantations to supply industrial and fuel wood, benefit indigenous tribal forest peoples, settle encroachers, and much else. Such tasks are those of governments—indeed of government at its best. But each nation has its own customs and problems, each government its own laws and procedures. A cartel structure, cartel goals, and cartel methods are too simple to take all these into account. What is needed is a Treaty Organization, and initially there would have to be a secretariat to establish a series of agreements (decla-

rations of intent) with individual governments, and coordinate their efforts until the actual OTEC Treaty was signed.

Although OTEC would be self-financing through membership dues, its start would have to be funded, and the availability of outside buffering finance for member countries during its early years might make the difference between its success and failure. And here a crucial point should be noted. There is not much public sympathy for artificially raising prices in the case of a commodity such as tin, silver, or cocoa; but there *is* grave public concern at the plight of tropical forests, and an organization designed to conserve them through a justifiable revaluation might therefore be supported without criticism by the World Bank, UNCTAD (a more effective use of their reforestation funds?) or other agencies.

IX

The details of such an organization are of course subject to substantial adjustment in the light of national circumstances and many other factors. My point is that, unless coordinated action of this sort is undertaken, the tropical rain forests of the world are doomed, through the uncontrolled operation of the forces described in this article. Their loss will be a calamity for the world as a whole—and of a magnitude and diversity that we are only now beginning to gauge.

To many, the solution I propose will not seem ideal. But clearly it would be in the national interests of the rain forest countries themselves, and in the medium and longer terms equally clearly it will be in the interest of the consuming countries and of the world as a whole. We have only a few years in which to set in motion such an organization. It should be urgently considered by all the countries concerned.

Mr. SCHEUER. Well, thank you, Mr. Rich. I have already expressed my appreciation to you for your many, many acts of helpfulness and kindness to this committee in helping to plan this hearing and other hearings. I repeat those thanks.

All right. Now we'll hear from Mr. Millikan for about 5 minutes.

Mr. MILLIKAN. Thank you.

Mr. SCHEUER. And I repeat, if I didn't say this to this panel, that your printed—your prepared testimony will be printed in full.

Mr. MILLIKAN. Thank you for the opportunity to speak before the subcommittee today on these issues which are so crucial to all of us.

My name is Brent Millikan, and for about 4 months during 1983 I worked as a field consultant for the independent Brazilian organization, which is responsible for the evaluation of the Northwest Brazil Integrated Development Project, Polonoroeste. And the name of the organization, which is evaluating the project, is FIPE, or the Economic Research Institute which is associated with the University of Sao Paulo.

And as I'm sure this subcommittee is aware, the Polonoroeste Program involves a very huge region of 410,000 square kilometers and a series of different components, the most important, of course, being the reconstruction and paving of the Cuiaba-Porto Velho BR-364 highway—which was originally budgeted at around $450 million.

The other major components of the program include settlement of new areas, consolidation of existing rural areas, land tenure services, health, environmental protection, and support to Amerindian communities.

OK. My own particular participation in the evaluation of the Polonoroeste Program involved a component known as the Rondonia Settlement Consolidation Sub-Project. The major objective of this aspect of—this major component of Polonoroeste, is to provide basic infrastructure and services to about 35,000 migrant families who are now living in these existing settlement areas along the BR-364 highway in Rondonia—the type of settlement areas which we saw in Adrian Cowell's film. There are several different aspects of the project of which agricultural research and extension are major aspects.

In essence, the philosophy of this Rondonia settlement consolidation project is based on the idea that providing these previously isolated settlers with access to roads, agricultural research and extension, improved inputs, and basic health and education services and other areas such as marketing, that by having access to these kind of services, these small settlers in Rondonia would become productive producers of basically perennial crops. Perennial crops are seen as a method of promoting both an economically viable kind of land use and at the same time ecological sustainability. And the main crops which would be promoted would be coffee, cocoa, and rubber.

Before I go on, I would just like to reiterate what I think has been brought out, which is that agricultural research in Brazil, in general, has been very much influenced by this predominant model of a "green revolution" approach to agriculture, which is very capital intensive, relying heavily on tractors, chemical fertilizers, im-

proved seeds and so on, and a certain export and industrial crops—the main ones being soybeans, wheat, sugar cane, cotton, oranges, and coffee.

The social and ecological consequences of this "green revolution" in Brazil have really been shockingly apparent. The so-called modernization of Brazilian agriculture has obviously benefited a few wealthy farmers in Brazil and the multinational corporations which dominate the markets of tractors, pesticides, and other such inputs. At the same time it has drastically increased concentration of land and rural incomes, pushing more and more of Brazil's small farmers off the land. In recent years, it has become clear that literally millions of the country's rural poor have been faced with this difficult choice: either moving to already overcrowded cities and facing the prospect of underemployment and a peripheral life in these areas, or migration to new frontier areas, predominantly in the Amazon, such as Rondonia.

At the same time this "green revolution" model of agriculture in Brazil has really had disastrous consequences ecologically. I think the most important thing we could point out is that this model of agriculture has been imported from temperate regions of the world, such as the United States and Europe, and it's really ecologically not suited to tropical countries such as Brazil. And since Mr. Lutzenberger is here today, who is one of Brazil's leading authorities on this subject, it might be interesting to ask what he feels the implications would be for U.S. agricultural research policies toward Third World countries and whether they are really addressing social and ecological issues.

OK. So, moving to the case of Rondonia, what has been evident traditionally in Rondonia and other areas of the Amazon is that agricultural research——

Mr. SCHEUER. Excuse me. Mr. Lutzenberger, I will ask you just exactly that question when these two witnesses are finished.

Mr. MILLIKAN. OK. Just to bring this into the context of Polonoroeste and Rondonia, it has been clear, including prior to the Polonoroeste project, that agricultural research and extension in Rondonia and other areas of the Amazon has basically followed this kind of capital-intensive monocrop kind of agriculture, which once again really denies the economic realities of the small producer, and at the same time becomes ecologically more absurd than it was in these other areas of Brazil.

So, through the Polonoroeste Program, I think there have been some improvements, particularly emphasizing more subsistance kind of crops, trying to minimize some of the inputs which are too expensive for the small farmer. At the same time, I think we should be really shocked at the current level of ecological devastation which is happening in areas in Rondonia. It is clear that the Polonoroeste project is not ameliorating this situation. In fact, it could very well be contributing to this process, specifically because of increased migration to Rondonia as a result of the asphalting of the BR-364 highway, which is also related to other problems—the increased migration, such as the current economic crisis in Brazil, and a continuing pattern of government propaganda which shows Rondonia as a kind of "El Dorado" in a solution to other problems in other areas of the country.

So, in terms of agricultural research and extension, like I said, in some respects there have been improvements. In other respects, the predominant model of monocrop agriculture seems to continue, which is largely inherited from these other regions of Brazil. A good example was, during my field study I looked at the question of what kinds of crops the extensionists were working with, and it was interesting to see that often these extensionists would be promoting things like citrus trees, which are grown in other parts of Brazil, and not taking advantage of this amazing diversity of native fruit trees that exist in the Amazon. It was really an amazing observation to see this. And so, in some respects, I think the Polonoroeste Program really has not been geared to the environmental and social realities which are so urgently needed to be taken account of in Rondonia.

OK. At the same time, what I would like to say is that there are two really crucial issues, I think, in terms of land use in Rondonia. One of the basic premises, like I said before, of the Polonoroeste project would be that it would be promoting perennial crops as an economically viable and ecologically sustainable kind of agriculture. What's really happening in Rondonia today, if one visits one of these settlement areas, small farmer settlement areas such as we saw in the film, is that many times the settlers are not able to establish these kinds of perennial crops such as coffee, cocoa, and rubber, for a variety of different reasons, including crop diseases, fluctuating prices on the international market for these export crops, difficult access to credit, interest rates which are just exhorbitant and impossible for the small farmer to take the chances of accepting this kind of credit.

So with all these difficulties in establishing these kinds of perennial crops, what's really happening in Rondonia today is a kind of conversion, a process of conversion to cattle pasture. This is not only in the large cattle ranches but within the settlement areas. With these difficulties in establishing crops, the colonists see pasture as an advantageous form of land use, for a couple of reasons. Cattle can be a source of reserve capital in case of sickness or some kind of bank debt. Many times colonists have bank debts because of problems in paying back loans because of agricultural problems.

At the same time cattle, or the introduction of cattle pasture, intrinsically will increase the value of the land, and this has been stimulated by the land rights legislation in Brazil. Or if the settler is trying to establish title over squatted lands, the act of deforestation and implantation of pasture will aid him. It seems a strange paradox that the destruction of this incredibly complex ecosystem and its substitution by a monocrop cattle pasture would result in its rising land values, but this is strangely the sad reality of development in the Amazon today.

At the same time that this——

Mr. SCHEUER. Mr. Millikan, I'm going to have to ask you to sum up, much as I regret to, because your testimony is marvelously interesting.

Mr. MILLIKAN. OK.

Basically what I'd like to say is that the model of perennial crop agriculture, which was envisioned in Polonoroeste, does not seem to be happening. There's a tendency toward cattle pasture in these

small farmer settlement areas, and at the same time, because of the difficulties that the settlers find in becoming successful, they're often selling their land—and there is already a land concentration process underway.

The asphalting of the BR-364 highway, since it will increase land values, will have a tendency to stimulate this process of concentration of land. At the same time the asphalting of the road will stimulate migration.

One thing I would like to briefly point out is that the phase III of the Polonoroeste Program plans to settle 15,000 small farmers, families, in Rondonia. At the same time, by 1980, there were at least 20,000 families without land in Rondonia waiting to receive land.

So the soils of Rondonia are also limited. About 10 percent are suitable for small farmer agriculture. So what's happening is many areas are spontaneously being invaded, and in my written testimony I give examples of areas of inappropiate soils on Indian reserves and the most pressing question I think is in the Guapore Valley, which is discussed in the written testimony. And although the World Bank is not directly funding this aspect of rural development in Rondonia, it directly violates one of the major conditions of the loan agreement. And I agree with Mr. Lutzenberger's assertion that the Bank should use its leverage to stop the current plans of the Brazilian Government as they are currently conceived.

So I'll conclude with that and can answer questions later.

[The prepared statement of Mr. Millikan follows:]

STATEMENT OF BRENT H. MILLIKAN

Chairman Scheuer and Members of the Sub-Committee,

I very much appreciate the opportunity to participate in this discussion today reviewing recent agricultural development projects in the humid tropical forest regions of Central and South America. I strongly believe that the World Bank-funded Northwest Brazil Integrated Development Program (POLONOROESTE) provides us with some particularly valuable insights into both the potential and the problems associated with rural development projects in the tropical forest regions of the world.

My name is Brent Millikan, and for approximately 18 months, during the years 1982 and 1983, I conducted field research concerning agricultural and environmental issues in Rondônia--a northwestern state of Brazil about the size of West Germany and part of the country's vast Amazon region. In addition to my own independent research carried out through a grant from the University of California, I spent the last four months of my stay in Brazil (September-December, 1983) working as a field consultant for the independent Brazilian organization responsible for the evaluation of the POLONOROESTE program: the Economic Research Foundation (FIPE) of the University of São Paulo.

As I believe the Sub-Committee is aware, the POLONOROESTE program involves a complex series of activities in both Rondônia and the central and western portions of the state of Mato Grosso. Its immense project-area covers a total of 410,000 square kilometers--about three-quarters the size of France or slightly less than 5% of Brazil's national territory. The most important aspect of POLONOROESTE, in terms of project costs, is the reconstruction

and paving of the 1,500 kilometer Cuiabá-Porto Velho highway (BR-364)--budgeted initially at about US$450 million. Other major components of the program include: settlement of new areas, consolidation of existing settlements, land tenure services, health, environmental protection, and support to Amerindian communities. According to the Treasury Department, the World Bank has to date made six loans totalling US$443.4 million for the POLONOROESTE program--about one-third of its total budget.

My own participation in the evaluation of POLONOROESTE involves a component known as the "Rondônia Settlement Consolidation Sub-Project", whose major aim is to provide basic infrastructure and support services to some 35,000 migrant families living in existing small-holder settlement areas along the BR-364 highway. Included in the sub-project's activities are: agricultural research and extension, construction and rehabilitation of rural roads, storage and marketing facilities, small-farmer organization, and basic health and educational services. Such assistance would be primarily diffused through a series of 39 Rural Support Centers (NUARs) to be strategically located in the interior of existing settlement areas.

In essence, the philosophy of this major component of the POLONOROESTE program is based on the premise that allowing previously isolated settlers access to basic infrastructure, support services, and rural credit will result in both increased rural incomes and the enhanced social well-being of the small-farmer population in Rondônia. In terms of agriculture, the project's plans focus on the promotion of perennial crops--particularly coffee, cocoa, and rubber--as both an economically-

favorable and ecologically-sustainable form of land use.

Before discussing the particular case of Rondônia, it is useful to point out that in Brazil, the activities of agricultural research and extension have been strongly influenced in recent years by a model of capital-intensive monocrop agriculture promoted by the federal government--focusing predominately on certain export and industrial crops (especially soybeans, sugarcane, wheat, cotton, oranges, and coffee). This classic "Green Revolution" approach to agricultural development has been heavily dependent on the use of modernized inputs--such as tractors, chemical fertilizers, high-yield seeds, pesticides, etc.

In terms of its social impact, the consequences of Brazil's Green Revolution have been shockingly apparent: While the so-called "modernization" of Brazilian agriculture has clearly benefitted the country's wealthier farmers and the multinational corporations which dominate the markets of modernized inputs, it has contributed to a drastic concentration of both land and rural incomes--pushing more and more small-farmers off the land.[1] In recent years, literally millions of Brazil's rural poor have been faced with a difficult choice: either the probability of underemployment and a marginalized life in already overcrowded cities, or migration to new "frontier" regions such as Rondônia--in the attempt to re-establish their already deprived access to land. Indeed, many of Rondônia's migrants come from the southern state of Paraná, where a massive rural exodus was recently caused when the federal government--through generous programs of subsidized credit and

other fiscal incentives--began a large campaign of promoting mechanized soybean cultivation for export markets.[2]

Moreover, the agricultural technology of the Green Revolution, since it is imported from temperate countries such as the United States, has often proven itself to be ecologically disastrous for tropical countries such as Brazil. As Mr. Lutzenberger is one of Brazil's leading authorities on this matter, the Sub-Committee may wish to question him on further details of this critical issue--including its implications for U.S. agricultural research policies towards Third World countries in general.[3]

In Amazonian regions such as Rondônia, the great challenge is to develop systems of agriculture and natural resource management which are both economically viable for the small producer and ecologically sustainable in the long run. Yet in Rondônia, agricultural research has traditionally reflected the mainstream model in Brazil of capital-intensive monocultures for export. Not only has this Green Revolution approach towards rural development once again been divorced from the economic realities of the small farmer, but it becomes even more of an ecological absurdity within an Amazonian context. In a similar manner, agricultural extension services in Rondônia have, over the years, typically been limited to the supervision of credit programs--narrowly focusing on a few cash crops and excluding the majority of settlers from any kind of technical assistance whatsoever.

Given this situation, the activities of agricultural research and extension in Rondônia have improved in several respects as a result of the POLONOROESTE program. Specifically,

more attention has been paid to diversifying extension services beyond credit programs, placing more emphasis on subsistence crops cultivated by settler families, and minimizing the use of expensive agricultural inputs. On the other hand, serious problems remain: With the extremely large settlement areas to be covered, it appears that many small-farmers may still not be reached by extension agents. The economic viability of several cropping systems and an effective integration between the government agencies responsible for agricultural research and extension remain to be satisfactorily proven.

Perhaps most importantly, the activities of agricultural research and extension implemented through the POLONOROESTE program seem to be having little impact on what can only be described as a process of immense ecological devastation currently taking place in Rondônia. The most serious of Rondônia's environmental problems concerns a pattern of rapid and indiscriminate deforestation occurring within small-farmer settlement areas. Indeed, since its emergence as a major "agricultural frontier" at the beginning of the 1970's, Rondônia has been one of the regions of the Amazon basin where the most intense rates of deforestation have been found.[4] According to Philip Fearnside, an American ecologist who works at Brazil's National Institute for Amazonian Research (INPA), if deforestation continues at its current explosive (and apparently exponential) pace, the entire state of Rondônia will be deforested by the year 1990! Similar calculations show that Rondônia's neighboring states of Acre and Mato Grosso would be completely deforested by the years 1993 and 1989, respectively, and most of the rainforests of the

Brazilian Amazon would be gone by the year 2,000![5]

What is so alarming about the current process of deforestation in Rondônia is not only its accelerated pace, but the indiscriminate manner in which it is occurring as well: on soils too infertile for agricultural use, on steep hillsides, and along the banks of rivers and streams. Although the Brazilian forestry code strictly prohibits such practices, it is simply not enforced.[6]

At the same time, this chaotic pattern of deforestation has been largely due to the policies of the Brazilian land agency, INCRA, whose settlement projects in Rondônia have usually consisted of a series of adjacent rectangular plots, designed along straight lines as access roads--with little or no regard to soil quality, topography, or the location of rivers and streams.[7]

It should also be mentioned that the question of uncontrolled deforestation has never been given adequate consideration by agricultural extensionists in Rondônia--a problem which has continued to be the case during the POLONOROESTE program. Most of Rondônia's migrants come from the more temperate regions of Brazil to the south, where ecological characteristics are quite different from those of the Amazon. Without any effective program of orientation, it is not surprising that the practice of slash-and-burn agriculture in small-farmer settlement areas would take place in areas where the forest cover should be preserved.

It is believed that there are as many as one million species of plants and animals in Amazônia. The mature upland forest (terra firme) in the Amazon basin is one of the richest biomes

on earth--containing at least 50,000 species of higher plants. The tropical forests of Rondônia have historically produced an abundance of wild rubber (Hevea brasiliensis) and Brazil nuts (Bertholletia excelsa). The fruits of the burití (Mauritia flexuosa), açaí (Euterpe oleracea) and tucumã (Astrocaryum vulgare), all native to the Amazon rainforest, contain three times as much Vitamin A as carrots. Other native fruits, such as the pupunha (Bactris gasipaes), araçá (Eugenia stipitata), camu-camu (Myrciaria dubia) cupuaçú (Theobroma grandiflorum), graviola (Anona muricata), and mapatí (Poruouma cecropiaefolia), are all not only well-adapted to the soils and climate of the Amazon basin, but possess a high nutritional value as well.

These and other plants have been used as food and medicine by Amerindians and the mixed-blood caboclos of the Amazon jungle for years. There is much that the migrant farmer in Rondônia could learn from those who have already adapted to living in a rainforest environment--without destroying it. Indeed, recent ecological and agronomic research in the Amazon basin has clearly shown that the most environmentally-sound cropping systems for the region seem to be those which mimic the diversity of the rainforest.[8] When Mr. Lutzenberger visited a family of rubber-tappers (seringueiros) in Rondônia, as shown in Adrian Cowell's film, The Decade of Destruction, he found them doing precisely this--mixing annual and perennial crops with tropical fruit trees.

Yet government policies and agricultural research institutions in Rondônia (as elsewhere in the Amazon) have continued to focus on the monocropping systems of "modernized" agriculture.

The Indian, the caboclo, and the seringueiro are all looked upon as "backward", as obstacles to "development". The rainforest is viewed only as something to be removed, not taken advantage of. During my field study in Rondônia, it was much more common to see an agricultural extensionist promoting the cultivation of citrus trees, grown extensively in the south of Brazil, than any of the native Amazonian fruits mentioned above.

The Amazon rainforest also possesses a wide variety of useful timber species. Yet if a settler in Rondônia wishes to sell any of the trees from a plot of forest he is about to clear and burn, he is likely to find that the local sawmill is interested in buying only one or two varieties--usually mahogany (Sweitenia macrophylla) and cherrywood (Amburana acreana)--which command the highest prices on the export market. The others are destroyed in the fire.[9] When the settler sells one of the few mahogany trees he might find on his plot of land, he is paid from 9 to 14 dollars per cubic meter. When the sawed wood is exported from the south of Brazil, it is sold for 450 dollars per cubic meter. The timber-exporting industry in Rondônia is dominated by large companies from south of the country. It's easy to see who is profiting from the destruction of the Amazon.[10]

As previously mentioned, the plans of the POLONOROESTE program for the small-farmer settlement areas of Rondônia are based on the promotion of perennial crops--especially coffee, cocoa, and rubber--as a means of achieving both increased rural incomes and ecological sustainability. However, the planting

of these crops by the small-farmer means overcoming a series of potential obstacles, including: scarcity of rural credit and prohibitively high interest rates, fluctuating international prices on export markets, high input costs, and crop diseases. At the same time, the migrant settler in Rondônia must also contend with such problems as a lack of roads during the rainy season, malaria and other illnesses, exploitation by intermediaries, etc. In short, if survival as a small-farmer was a difficult task in the south of Brazil, it is often more so in an Amazonian region such as Rondônia.

Given the above-mentioned problems, what is being witnessed in Rondônia today is typically not the prosperous expansion of perennial crops--as envisioned in the plans of the POLONOROESTE program. Instead, there is a general tendency for land within the small-farmer settlement areas to be converted to pastures for cattle-grazing. Besides being a low labor-intensive activity, cattle may provide the financially-squeezed settler with an important souce of reserve capital--especially in emergency cases of a family illness or bank debts. On the other hand, when the small-farmer in Rondônia clears a plot of forest and plants cattle pasture, he increases the land's intrinsic value, or his chances of imminent domain over squatted lands--a process which has been stimulated by INCRA's land rights legislation. It seems strangely paradoxical that the destruction of one of nature's most complex and exquisite ecosystems, the Amazon rainforest, and it replacement by a monocrop, cattle pasture, would result in an increase in the land's value. Yet this is the logic of Amazonian "development".

When visiting a small-farmer settlement project in Rondônia, one may be surprised to find large areas of pasture lands, but very few cattle. This is the case simply because most settlers lack the necessary capital to purchase a number of cattle proportionate to their areas of pasture. Indeed, one recent field study by Rondônia's State Agricultural Planning Commission (CEPA-RO) showed that while roughly 80% of the settlers surveyed were expanding their areas of pasture, less than 40% owned any cattle at all. When pastures in tropical forest regions such as Rondônia are abandoned, they are quickly invaded by noxious weeds which are unpallatable to cattle as fodder. Thus, the end-product of the destruction of the Amazon rainforest is often a form of land use which produces absolutely nothing. Moreover, recent research on cattle-grazing in the upland terra firme regions of the Amazon basin has raised other serious questions concerning its ecological sustainability--due to such problems as declining soil fertility, erosion, and soil compactation.[11]

Another disturbing trend that may be observed in Rondônia today concerns a process of land concentration within the small-farmer settlement areas assisted by the POLONOROESTE program. With the previously-mentioned difficulties of becoming a successful small-farmer in Rondônia, many of the settlers have been forced to sell their plots of land due to financial burdens. Such a reality sharply contrasts one of the basic objectives of the Rondônia Settlement Consolidation Sub-Project and the POLONOROESTE program in general: the productive "fixing" of the small-farmer to the land. Furthermore, with the asphalting of the Cuiabá-Porto Velho highway and other road infrastructure

implemented through the POLONOROESTE program, it appears inevitable that increasing land values will further stimulate this process of land concentration in small-farmer settlement areas. As land becomes concentrated in fewer and fewer hands, the tendency is for its subsequent conversion to cattle-pasture.[12]

As one Northeasterner who migrated to Rondônia during the rubber boom of the 1940's once commented to me: "At first, there was only the Indian here in Rondônia. Then the rubber-tapper came and moved onto his land. Next came the migrant settler, clearing the forest and pushing the rubber-tapper off the land. Now it's the cattle rancher's turn to come and buy up the land of the settler."

Another significant impact of the asphalting of the Cuiabá-Porto Velho highway--especially within the context of the current economic crisis in Brazil and continuing government advertisement heralding Rondônia as the country's new "El Dorado"--is the tendency for already intense rates of migration in the Northwest region to accelerate even further. By the end of July 1984, 112,200 new migrants had been registered in Rondônia this year along border checkpoints on the BR-364 highway--an increase of over 100% in comparison to the same period last year![13]

While slightly less than half of these new arrivals were destined for rural areas,[14] it is crucial to recognize that Rondônia's capacity to absorb such large numbers of migrant farmers is extremely limited--in both an administrative and environmental sense. According to the World Bank's most optimistic estimate, only 10% of the state's soils may be considered adequate for cultivation of annual or perennial crops on a

sustained basis[15]--and the great majority of these soils are already occupied.

With growing land pressures in the Northwest region, it appears that the problems of indiscriminate deforestation and settlement on unsuitable soils, invasions of Amerindian lands and natural reserves, and other violent land conflicts will continue at an alarming rate--despite the objectives of the POLONOROESTE program.

One recent example of this type of problem concerns the Lourdes Indian Park in Rondônia, where approximately 400 squatter families have invaded the lands of the Gavião and Arara Indians. Despite protests from local representatives of Brazil's National Indian Foundation (FUNAI), government authorities have balked at having the squatters legally removed. Within the past month, tension on the Lourdes reserve increased to the point that the Indians took several of the squatters as hostages as a means of pressuring the government to resolve this problem.

My colleagues at FIPE responsible for the evaluation of the Amerindian component of POLONOROESTE have informed me that despite promises made by the Brazilian government in the loan agreement with the World Bank, the majority of the indigenous areas in the project region have not been fully demarcated and protected against invasions.[16] Similarly, it appears that the Brazilian Institute of Forestry Development (IBDF) and the Special Secretariat for the Environment (SEMA) have lacked the administrative and/or political capability to adequately protect their respective reserve areas financed through the

POLONOROESTE program.[17]

The New Settlements Project (Phase III) of POLONOROESTE involves the settlement of approximately 15,000 migrant families in Rondônia. Yet by 1980, there were already an estimated 20,000 migrant families in the state waiting to receive land from INCRA[18]--a number which has undoubtedly increased substantially since then. While Phase III of POLONOROESTE has attempted to incorporate improved ecological zoning (in terms of soils, topography, and hydrographic characteristics) and basic farmer services in its settlement projects, a much larger number of migrants are spontaneously invading lands on the periphery of existing small-farmer areas, or being settled by the government under extremely precarious conditions.

Currently, the most disturbing example of this process concerns the Brazilian government's plans to settle an estimated 10,000 migrant families along the nearly-completed Presidente Medici-Costa Marques highway (BR-429) in the Guaporé Valley of Rondônia. As Mr. Lutzenberger has correctly pointed out, this region of mostly-pristine tropical forest has been shown to possess soils which are largely unsuitable for small-farmer agriculture.[19] Indeed, one high-ranking official of Rondônia's Secretariat of Agriculture privately stated that the majority of the soils in the Guaporé Valley will produce no more than three years before they are abandoned.

Moreover, the opening of the BR-429 highway in the Guaporé Valley will no doubt provoke a spontaneous wave of migration into the region, posing a serious threat of invasions to several reserve areas funded through the POLONOROESTE program. These

include the Guaporé Biological Reserve, the Rio Branco Indian Park, the Pacaas Novos National Park, and the still-undemarcated lands of the Uru-eu-wau-wau Indians, (among the last indigenous groups of the Amazon basin still not in permanent contact with the outside world).[20]

In short, the Brazilian government's plans for the settlement of the Guaporé Valley promise to be nothing short of a human and ecological catastrophe. Although the World Bank is not directly involved in financing this aspect of Rondônia's rural development, it does represent a clear violation of section 3.13 of the loan agreement for Phase I of POLONOROESTE, which states,

> The Borrower and the Bank agree that the orderly development of areas of the Program-Area most suitable for agricultural development and that the environmental protection of areas determined to be unsuitable for agricultural development are essential to the successful carrying out of the Project. To this end, the Borrower shall take all necessary measures: (a) to discourage the agricultural exploitation of areas which have been determined to be unsuitable for agricultural development or of areas whose suitability for agricultural development has not yet been determined; and (b) to prevent the occupation of areas which have been legally defined as reserves.

Given this situation, I fully support Mr. Lutzenberger's assertion that the World Bank should use its full leverage to ensure that this imminent human and ecological disaster in the Guaporé Valley of Rondônia is avoided.

Finally, it should be pointed out that the asphalting of the Cuiabá-Porto Velho highway will not only stimulate the process of uncontrolled migration and deforestation in the immediate project-area of POLONOROESTE, but within a much

larger region in the western Amazon basin as well--including the states of Amazonas, Acre, and Roraima where a large proportion of migrants are now moving. As Fearnside has emphasized,

> The asphalting of the Cuiabá-Porto Velho highway (BR-364) will remove a major impediment to a more accelerated population flow into the western Amazon region, thus increasing the probability that the areas near the upper Solimões and Negro rivers, together with their tributaries, will cease to be the most untouched extension of forest (in the Brazilian Amazon basin).[21]

In summary, I believe it is possible to arrive at the following conclusions and recommendations concerning the World Bank's involvement in the POLONOROESTE program:

-In 1979, the federal government of Brazil approached the World Bank to discuss a possible loan for the reconstruction and asphalting of the Cuiabá-Porto Velho highway (BR-364). After considerable debate concerning the potential negative impacts of the project--particularly on the Amerindian communities and fragile natural environment of the region--the Bank announced in December 1980 that it would consent to financing the highway project as part of the larger development package described above. In essence, the World Bank's decision to finance the POLONOROESTE program was justified by the belief that with or without the Bank's participation, the Brazilian government would procede with its highway development plans. Therefore, by funding an overall development program, it was argued that the Bank would be using its leverage to promote basic human and ecological concerns in the Northwest region of Brazil.

-In some respects--as in the case of the removal of squatters from the lands of the Suruí Indians or the demarcation of the Nambiquara territory[22]--the World Bank has definitely made such a contribution through the POLONOROESTE program. As previously mentioned, the activities of agricultural research and extension through the Rondônia Settlement Consolidation Sub-Project of POLONOROESTE have improved in certain areas largely as a result of the Bank's participation in the program. However, while the reconstruction and asphalting of the Cuiabá-Porto Velho highway was recently completed ahead of schedule,[23] many other aspects of POLONOROESTE--especially those pertaining to small-farmer assistance, environmental protection, and support for Amerindian communities--have not been satisfactorily implemented and/or have not reached their stated goals. Moreover, there are already strong indications that the paving of the BR-364 highway through the POLONOROESTE program will ultimately contribute to the problems of chaotic land settlement and ecological destruction in the Northwest region.

-Given the above situation, it would appear that the World Bank has seriously underestimated the difficulties associated with implementing the stated human and ecological concerns of the POLONOROESTE program. Moreover, many of the current problems in the Northwest region were foreseeable at the outset of the project. Indeed, when one examines the policies and institutions of the Brazilian government associated with rural development in general, it becomes clear that the necessities of the small-farmer, environmental

preservation, and protection of Amerindian communities have all been largely neglected in the past.[24] Is it reasonable, therefore, to assume that "integrated rural development projects" such as POLONOROESTE will easily change the overall development priorities of countries such as Brazil? At the same time, one must invariably ask the question: Should the World Bank consent to financing large-scale development projects in such highly volatile regions as Rondônia which are clearly "escape-valves" for socio-economic inequalities in other regions of the country? In addition to helping prolong the day when these social imbalances must eventually be addressed, will not the project--through the construction of roads and other infrastructure--ultimately contribute to a chaotic process of human settlement and environmental degradation over which it will have little, if any, control?

-At present, I believe there is an urgent need for the World Bank to re-evaluate the activities of POLONOROESTE regarding agricultural development and environmental protection in the Northwest region--ensuring the adequate implementation and/or upgrading of relevant project components. In particular, it seems crucial that more attention be given to the current pattern of indiscriminate deforestation and unsustainable forms of natural resource use in small-farmer settlement areas. In terms of agricultural research and extension, it is clear that beneficial results could be obtained by placing more emphasis in such areas as deforestation zoning, recuperation of degraded lands, multi-cropping systems, use of native species and indigenous resource knowledge, etc.[25]

-Finally, it is absolutely essential that the World Bank use its full leverage to ensure that the environmental and Amerindian components of POLONOROESTE are adequately implemented. At the same time, the Bank should obtain guarantees from the Brazilian government that it will cease its continuing propaganda campaigns which further stimulate migration to the Northwest region. Given that the federal government of Brazil accomplished its major objective with the completed asphalting of the Cuiabá-Porto Velho highway, the World Bank's leverage could plausibly include the threat that unless conditions of the loan agreement for the POLONOROESTE program are met, the Bank will re-consider funding for other development projects in Brazil--one of its major recipient countries.

NOTES

1. Between 1970 and 1980, the poorest 50% of Brazil's rural population saw its share of the country's total rural income decline from 22.4% to 14.9%, while the richest 5% increased its share from 23.7% to 44.2%. (Campanha Nacional pela Reforma Agrária, CONTAG, CPT, CIMI, CNBB, IBASE; Editora Codecri, Abril 1983, p.12) In terms of land tenure, it is estimated that a mere 1% of the farms in Brazil control over 43% of the country's farmland, while 50% of the farms are left with less than 3% of the land. In addition, at least 7 million rural families in Brazil own no land at all. (Lappé, Frances M. & Collins, Joseph. "Food First: Beyond the Myth of Scarcity", Ballantine Books, New York, 1979, P.49)

2. During the decade of the 1970's, the substitution of mechanized soybean and wheat cultivation for coffee in Paraná was directly responsible for the rural exodus of over 1.2 million people. While the state absorbed 3.9 million rural workers in 1970, this number has declined to less than 1.8 million today. In terms of land tenure, the number of rural properties in Paraná fell from 554,000 in 1970 to 478,000 only five years later. Presently, there are approximately 454,000 rural properties in the state. The properties most affected by this process of land concentration have been those small-holders with less than 10 hectares: In 1970, there were an estimated 295,000 such properties in Paraná. Ten years later they had declined to less than 216,000. (Jornal SEAGRI, "Concentração de Terras Promove Mais Desemprego", Ano 6, No.63, Maio 1983, p.6)

3. One excellent source of information on both the social and ecological impacts of Brazil's Green Revolution is Francisco Graziano Neto's book, "Questão Agrária e Ecologia: Critica da Moderna Agricultura", Editora Brasiliense, São Paulo, 1982, 154 pp.

4. For example, between 1975 and 1978, the deforested area in the municipality of Cacoal skyrocketed from 2,250 hectares to 66,950 hectares--an increase of 2,900% during this three-year period! (Fearnside, Philip M. "Deforestation in the Brazilian Amazon: How Fast is it Occurring?", Interciência, Vol. 7, No.2, March-April 1982, pp.82-88) According to the latest available data from LANDSAT satellite images, during the period of 1978-1980, the deforested area in the entire state of Rondônia rose from 418,450 hectares to 757,928 hectares--an increase of 339,448 hectares (or 1.39% of the state's total land surface) in only two years! (Ministerio da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal (IBDF), "Alteração da Cobertura Vegetal Natural do Estado de Rondônia", Programa de Monitoramento da Cobertura Florestal do Brasil, Relatório Técnico, Brasília, D.F., 1982, 68 p.) Although the majority of this deforested area is included in small-farmer

settlement areas (see page 25), a substantial amount of deforestation has also taken place on large cattle ranches--in such areas as the Gleba Corumbiara. It should also be mentioned that satellite data for deforestation rates in the Amazon region are usually underestimated, since interpretations of LANDSAT images frequently do not detect small clearings or the difference between primary forest and secondary growth. (Fearnside 1982, op.cit.)

5. Fearnside, Philip M. "A Floresta Vai Acabar?", Ciência Hoje, (Edição Especial: Amazônia, 1984), Sociedade Brasileira para o Progresso da Ciência, Vol. 2, No. 10, Janeiro-Fevereiro de 1984, pp. 43-52

6. See articles #2 and #27, Codigo Florestal Brasileiro, Lei No. 4771, Ministerio da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal (IBDF), Brasília, D.F., Novembro de 1977. The government agency responsible for enforcing the forestry code, the Brazilian Forestry Development Institute (IBDF) has consistently lacked the institutional capacity at the local level for carrying out this task--a situation which has persisted during the implementation of the POLONOROESTE program.

7. At the same time, INCRA has possessed neither the financial resources nor administrative capacity to accompany the intense rates of migration to Rondônia since 1970--resulting in a several lack of infrastructure and basic services within its small-farmer settlement areas and a pattern of spontaneous invasions and land conflicts in adjacent areas.

8. See for example: Hecht, Suzanna (ed.) "Amazônia: Agriculture and Land Use Research", proceedings of the International Conference on Amazonian Agriculture and Land Use Research, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, 1982, 428 p.

9. According to the plans of the POLONOROESTE program, a series of salvage logging studies would be conducted by IBDF with the aim of promoting greater utilization of timber which otherwise would be lost when the forest is cleared for planting crops. Unfortunately, there has to date been little progress on this aspect of the project.

10. In fact, these timber-exporting companies will be among those who benefit most from the asphalting of the Cuiabá-Porto Velho highway, since their transport costs to the southern ports of Brazil will diminish considerably. Given this situation, this may be yet another way in which the POLONOROESTE program contributes to increased deforestation in the Northwest region.

11. See: Fearnside, Philip M. "The Effects of Cattle Pasture on Soil Fertility in the Brazilian Amazon: Consequences for Beef Production Sustainability", Tropical Ecology, Vol. 21, No. 1, 1980, pp. 125-127; Goodland, Robert J.A. "Environmental

Ranking of Amazonian Development Projects in Brazil", Environmental Conservation, Vol.7, No.1, 1980, pp.9-26; and Hecht, Suzanna. "Cattle Ranching Development in the Eastern Amazon: Evaluation of a Development Strategy", Phd Dissertation, Department of Geography, University of California, Berkeley.

12. To date, the purchasers of these plots sold (usually through "unofficial" means) in small-farmer settlement areas have typically been either better-off settlers or residents of local urban areas--including merchants, gas station owners, government officials, local professionals, etc. However, with rising land values in Rondônia (stimulated further by the asphalting of the Cuiabá-Porto Velho highway), it is likely that the process of land speculation by large investors from the Center-south of the country--which has already occurred both in Rondônia and in other areas of the Brazilian Amazon such as along the Transamazon highway--will tend to increase.

13. State Agricultural Planning Commission of Rondônia (CEPA-RO), personal communication, September 1984.

14. It is interesting to note that in recent years, an increasing proportion of Rondônia's migrants have originated from urban areas--usually being classified as semi or non-skilled laborers. Many of these people are fleeing the high unemployment and miserable living conditions of large cities in other regions of Brazil. Yet in Rondônia--despite the claims of government advertisements--the capacity of the state's towns and cities to provide employment for this large contingent of migrants is very limited.

15. World Bank, "Brazil: Integrated Development of the Northwest Frontier", Latin American and Caribbean Regional Office, Washington, D.C., June 1981, p.58

16. According to Betty Mindlin, the anthropologist who coordinates the team evaluating the Amerindian component of POLONOROESTE, the following indigenous areas in the project-region were, as of March 1984, still awaiting demarcation:

a) the territory of the Uru-eu-wau-wau, together with the necessary disanpropriations, since there are persons with land titles living in the area;

b) the Karipuna territory;

c) the Zoró territory;

d) the area interdicted for the Cinta Larga;

e) the area of the Irantxe, with a new definition of the boundaries of the area;

f) the area of the Salumã;

g) the area of the Pareci, with delimitation and

and demarcation of the Formoso, Estivadinho, and Capitão Marcos areas, and inclusion in the Pareci territory of the area north of the 14th parallel;

h) the area of the Kaxarari;

i) redefinition of the Bakairi territory, to include lands justifiably claimed by the Indians on both the Bakairi and Santana Indian Parks;

j) definition and demarcation of lands for the Mequém;

l) reconstitution of the Urubu group, with the definition of lands for the tribe;

m) the completed demarcation of the Nambiquara territory, including indemnification and removal of cattle ranches in the area and final registration in the Serviço de Patrimonio da União.

Moreover, Professor Mindlin states that there have already been serious invasions on the majority of indigenous areas within the POLONOROESTE project-region. Therefore, "either these lands are demarcated and defended now or the Indians will disappear in four or five years with the massive immigration (to the Northwest region)". (Betty Mindlin, personal communication, March 1984).

The above situation thus represents a direct violation of section 4.05 of the loan agreement for the first phase of POLONOROESTE, which states,

> The Borrower and the Bank agree that the strengthening of the measures to protect the indigenous Amerindian population in the Program-Area is essential to the successful carrying out of the Project. To this end, the Borrower shall take all necessary measures to put into effect promptly the Special Project for protecting the interests of the Amerindians and the Amerindian communities located in the Program-Area.

17. In Rondônia, there have already been invasions reported on the Guaporé and Jarú Biological Reserves, the Pacaas Novos National Park, and the Cuniã Ecological Station.

18. Lopes, Eliano S.A. "Colonização Agrícola em Rondônia: A Relação Parceleiro-Agregado como Manifestação da Resistência a Expropriação", Universidade Federal Rural do Rio de Janeiro, Tese de Mestrado em Desenvolvimento Agrícola, 1983, p.70

19. The poor agricultural aptitude of these soils is clearly visible in the soil maps of EMBRAPA/SNLCS published in 1983, (scale of 1:500,000): "Mapa de Levantamento de Reconhecimento

de Media Intensidade dos Solos do Estado de Rondônia", Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Serviço Nacional de Levantamento e Conservação de Solos (SNLCS), Brasília, D.F., 1983.

20. The planned route of the Presidente Medici-Costa Marques highway (BR-429) passes directly through an area where violent contacts between unknown Indians and outsiders have taken place in 1981 and 1983. At present, the final 90 kilometers of the BR-429 highway are scheduled to be completed by November, 1984. (CEPA-RO, personal communication, September 1984).

21. Translated from: Fearnside (1984, op.cit., p.48)

22. When the Suruí were first contacted in 1969, their population numbered an estimated 600 people. However, as a result of uncontrolled invasions and subsequent contacts with outsiders, at least half of the group died between 1971 and 1974--mostly from influenza and measles. With pressure from the World Bank, the final removal of squatters from the Sete de Setembro Indian Park took place in 1981. For more information, see Betty Mindlin's article on the Suruí Indians in the Cultural Survival report: "In the Path of POLONOROESTE", Occasional Paper No.6, October 1981, pp. 53-54.

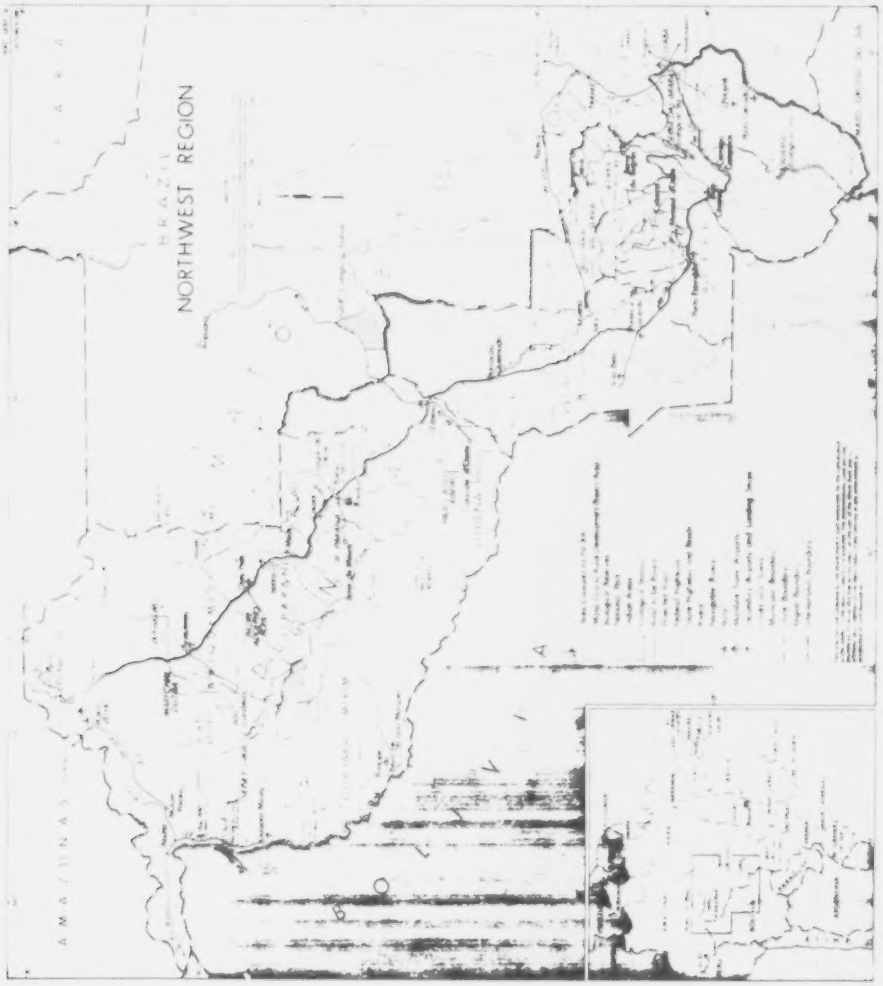
According to Professor Mindlin, the demarcation of the Nambiquara territory is probably the most important accomplishment to date of the Amerindian component of POLONOROESTE. However, as previously noted, the demarcation process for this area remains to be legally completed.

23. The asphalting of the Cuiabá-Porto Velho highway (BR-364) was officially inaugurated last Thursday, September 13th, by Brazilian President João Batista Figueiredo.

24. In terms of the Amazon region of Brazil, see for example: Davis, Shelton H. "Victims of the Miracle: Development and the Indians of Brazil", Cambridge University Press, 1977, 205 p., and Moran, Emilio F. "Developing the Amazon: The Social and Ecological Consequences of Government-Directed Colonization Along Brazil's Transamazon Highway", Indiana University Press, Bloomington, 1981, 292 p.

25. At the same time, my field research for FIPE concludes that other major improvements (in the areas of road construction, storage and marketing, small-farmer organization, health, and education) need to be made in the Rondônia Settlement Consolidation Sub-Project of POLONOROESTE--so that such assistance may become sufficiently accessible to the small-farmer population. Indeed, the previously-mentioned process of land concentration due to small-farmer failures in Rondônia testifies to the importance that such measures be taken.

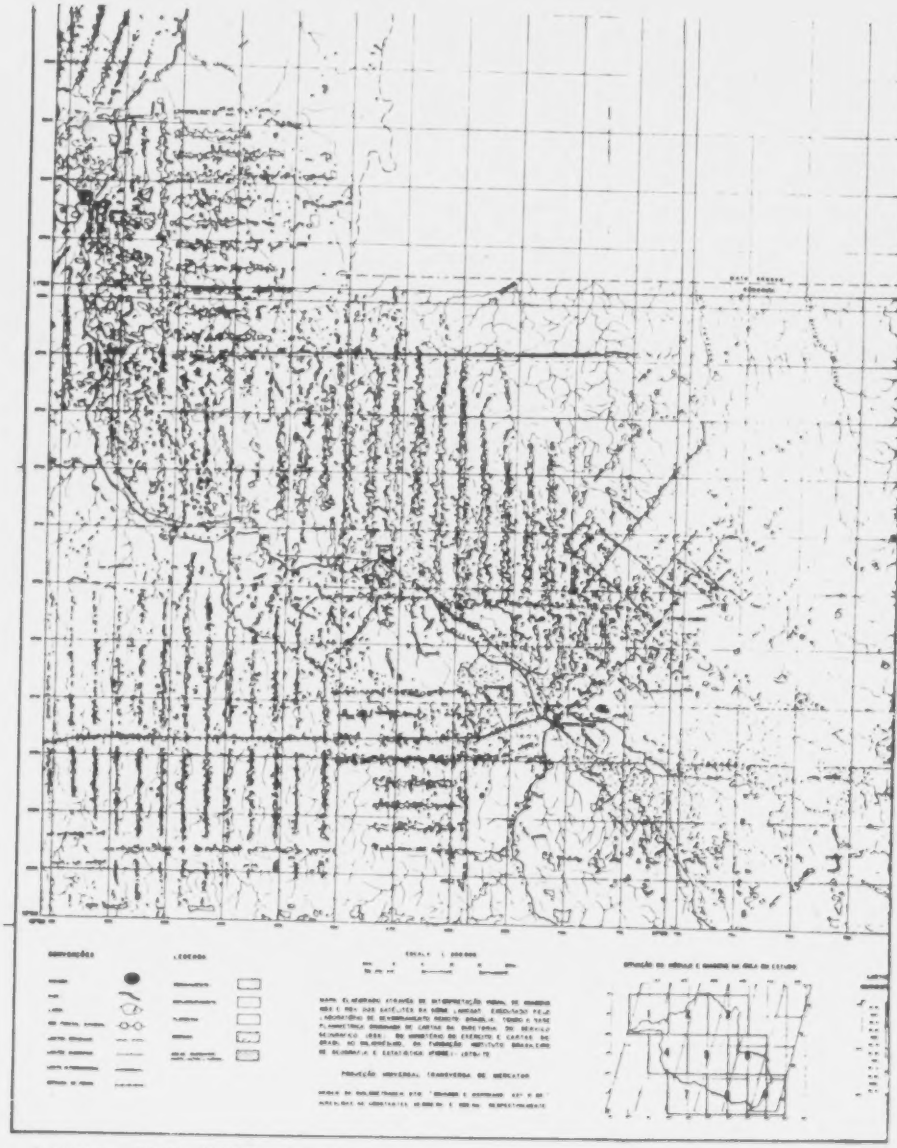
Project-Area of the Northwest Brazil Integrated Development Program
(POLONOROESTE)



source: World Bank

Deforestation in Small-Farmer Settlement Areas (by 1980)
Vicinity of Cacoal, Rondônia

(Shaded Areas Represent Forest Clearings)



Source: IBDF (1982, op.cit.)

Deforestation in Small-Farmer Settlement Areas
Rondônia, Brazil, 1983

Mr. SCHEUER. Thank you very much, Mr. Millikan. We were very much—we are very much impressed by your testimony. It was extremely interesting.

All right. Miss Barbara Bramble, representing the National Wildlife Federation, if you could give us your testimony in about 5 minutes.

Ms. BRAMBLE. I will. Thank you, Mr. Chairman.

Mr. SCHEUER. Then we'll have some questions for you.

Ms. BRAMBLE. I will summarize very quickly.

I would like to draw back from some of the specific focus on projects, as we have been talking about today, and talk about the overall pattern and give you the perspective of the National Wildlife Federation, which as you know is the Nation's largest conservation group.

Our 4 million members and supporters are dedicated to the wise use of natural resources, and as I'm sure you know, one of the major and most valuable resources on this Earth are the tropical forests. We are concerned that certain kinds of economic development have been and are continuing to cause destruction of vast amounts of these forests without compensating value in return and the development is not sustainable. So, in other words, we have an ironic paradox. One the one hand, agriculture and livestock expansion is threatening to wipe out vast stands of the valuable tropical timber and the complex forest ecosystem, but on the other hand, since the functions of these ecosystems are still being deciphered, the physical limitations of tropical forests, the land in tropical forest areas, is threatening the actual future productivity of the agriculture and livestock project. So it is a reciprocal cycle.

I don't think I'm going to want to go into any detail today about why this is happening. Suffice it to say that there are many factors and different reasons for the pressure that's being placed on the forests, and there is certainly no single villain. But a major role is being played by the development agencies that are promoting inappropriate models for economic development in tropical forests.

Today we are hearing about specific problems associated with projects in the Brazilian Amazon and in Panama, but the pattern has been or is being repeated in Colombia, in Peru, and farther afield in the Far East, particularly in Indonesia, to name just a few. Staff of such institutions as the World Bank and others will tell you privately that they know the agricultural yields from these jungle settlement projects will not last; they know the settlers cannot afford the inputs that are needed to farm these tropical soils that they have been telling them to use; and that they know that these areas should be the last priority for such development. But still, the sad process continues, of opening the tropical forests, a few short years of cultivation, and then abandonment of the resulting unproductive scrubland.

Tropical forests are too valuable to be wasting in this way. We believe that a whole new approach is needed to promote stable, sustainable use of forest lands that have already been opened, and reforestation of the degraded lands. The first step will require acceptance of a new model of development, at least for the foreseeable future, allowing for small farms, with diverse crops, low commercial inputs, and more intensive use of labor.

Research relating to agriculture in tropical forest areas is a prime example of the needed change in emphasis. Up 'til now, as you know, most of the agricultural research has been dominated by the land grant universities in this country, and the 13 international agricultural research stations under the Consultative Group on International Agricultural Research. The latter organization now receives a considerable portion of its funds from the World Bank. This is the center that spearheaded the green revolution, and that has been mentioned a couple of times here today. The breakthroughs which produced the new high-yielding varieties of wheat and rice, particularly under the green revolution, have raised production in many parts of the world, but they have also resulted in considerable controversy over the equitable distribution of food, credit opportunities, and profits, as well as the ecological threats such as widespread pesticide contamination. But regardless of the success of these new varieties where they have been introduced, the fact remains that millions of small farmers cannot use them for lack of funds, transportation, or other reasons.

So, instead of trying to import inappropriate crops and techniques for temperate climates, and to use mechanized agricultural systems, the research institutions interested in developing countries have to concentrate on appropriate crops, cultural methods, and tools for the small farmer.

As has been mentioned here earlier, one of the most appropriate avenues for this research would be agroforestry. Many different kinds are possible. This is where tree and annual crops are grown together.

One promising variant of agroforestry is called the Chinampa. It deserves particular attention because it was a way for ancient people in Central America, the Maya cultures, to support a large number of people for a long period of time on fairly limited land area. I describe that in my testimony. If you'd like further information on it, I would be glad to get it for you. Similar work, of course, is needed on simple forms of integrated pest management.

Another important but neglected avenue for research is the sustainable use of the products of the existing forest. The Brazil nut tree was discussed today, and that's one of the most current available examples that will show the productivity and potential of using the forest as it is.

At the same time, besides research, extension workers and consultants are needed who understand the diverse needs of the small farm, not the single-crop experts who are commonly hired today.

I would like to conclude by saying that the current rapid rates of tropical deforestation are the result of many factors, including the demand for timber and beef in this country. But one of the major causes is the expansion of agriculture from both planned settlements and the spontaneous colonization that has been discussed today. The pressures caused by this expansion could be reduced significantly if promising research leads in agroforestry and other appropriate small-scale agriculture technologies were successfully implemented. The key actors in filling the present knowledge gap would be the CGIAR and the U.S. land grant agricultural research establishments, with funding from the bilateral and multilateral development agencies. They should also be allocating significant

funds to establishing data on the land capability before they go into agriculture development projects.

I would like to support the recommendations that were outlined by Mr. Rich today, particularly those related to the multilateral development banks. There may be a reluctance to devote significant resources to these different approaches, but I think a major effort is needed. And this country can, I believe, bring the pressure to bear to make that happen.

The National Wildlife Federation urges you to expand on this first hearing and to continue your investigation into other significant gaps in research needed for sustainable agriculture. I think that strong recommendations from this subcommittee would be persuasive in shifting research priorities toward more appropriate agricultural development.

Thank you.

[The prepared statement of Ms. Bramble follows:]

NATIONAL WILDLIFE FEDERATION

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STATEMENT OF BARBARA J. BRAMBLE
ON BEHALF OF
NATIONAL WILDLIFE FEDERATION

BEFORE THE
SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

Agriculture Development and Tropical Deforestation

Mr. Chairman, on behalf of the National Wildlife Federation, I am pleased to have the opportunity to appear here today, in the first of a series of investigations by this Subcommittee into the interconnections between agricultural development and natural resources conservation in developing countries. We hope that these hearings will result in concrete recommendations for research and demonstration projects aimed at promoting ecologically sustainable agricultural systems suitable for developing countries.

The National Wildlife Federation, the nation's largest conservation organization, with over 4 million members and supporters, is dedicated to the wise use of natural resources. The Federation has long believed that economic development depends on the sound management of natural resources such as forests, agricultural soils, and water supplies. This is nowhere more apparent than in agriculture in tropical countries.

Our focus today is on agriculture in the humid tropics, although equally tough problems are posed by agriculture in tropical arid zones. The latter are so drastically different that they would logically form the subject of a separate inquiry. In the humid tropics, sustainable development is hampered by two, ironically reciprocal, tendencies: On the one hand, agricultural expansion threatens to wipe out vast stands of valuable tropical timber and complex, barely understood, forest ecosystems. On the other hand, however, since the functions of these ecosystems are still being deciphered, the physical limitations of tropical forest lands are threatening the future productivity of the agricultural projects.

Tropical deforestation is of particular concern because, as a whole, the humid tropical forests contain perhaps half the species of plants and animals living on the earth, though they comprise only 7% of the earth's surface. They also seem to be major actors in the earth's climate and in regional hydrological cycles. These forests, and the genetic diversity they contain, are being invaded and cut at a rapidly increasing rate; by the end of the century, it is expected that only the most remote tracts will remain in their current undisturbed state.

Along with unsustainable rates of timber harvest, agricultural expansion is one of the leading causes of tropical deforestation. But the resulting agricultural yields are often much less than expected.

The problems of agricultural production in humid tropical regions are many and well-documented. See Ecological Aspects of

Development in the Humid Tropics, Committee on Selected Biological Problems in the Humid Tropics, National Research Council, National Academy Press, 1982. A detailed discussion of the reasons is unnecessary here, but a brief outline may be useful. The major problems are that most of the suitable soils are already in use; that remaining tracts of tropical forests are tempting targets for development; but that, generally speaking, the soils underlying these forests are thin, easily eroded and infertile. Removal of the forest cover exposes them to violent rain and sun, and allows remaining nutrients to be leached out. Most of the nutrients supporting a tropical forest are found above ground in the trees themselves, not in the organic matter in the soil, as is the case in most temperate forests. Therefore, when tropical trees are felled and burned, their nutrients are available in the form of ash for a short time, but are soon washed away.

When human population was low, these characteristics of tropical forest regions posed no insurmountable problems for agriculture. Small plots were cleared, used for three years or so for grains and vegetables and then for tree crops, and eventually abandoned to forest regeneration. The farm family would meanwhile move to a new plot nearby, allowing the cleared area to recover. This process, known as slash and burn or shifting cultivation, has been practiced for thousands of years. It becomes a problem only when human population grows so large that the forest clearings must be re-cut and cultivated before they have fully recovered.

But, for the same reasons, permanent cultivation schemes, often promoted by development agencies, are highly unlikely to succeed on tropical forest land. Special provisions must be made to protect the soils from rainfall and tropical sun, and to provide a continuing source of nutrients. Annual crops, which are often promoted, are particularly unsuitable, because their roots fail to hold the soil and they leave large areas of ground uncovered during part of the growing season. In addition, commercial fertilizers are usually beyond the means of the poor farmers settled on these project lands; and such inputs are often unavailable when needed, due to transportation and other logistical difficulties. Thus, in many such projects low yields discourage the settlers. Many have abandoned their land or sold out to cattle ranchers who can use the land for a few more years of low-level grass and beef production. In the end, many acres of biologically-rich tropical forests are turned into useless scrub, abandoned even by the cattle.

This sad and unproductive process has been repeated in many parts of Central and South America, as well as Southeast Asia and elsewhere. Among the worst examples are agricultural settlement schemes funded in recent years by several of the MDBs, and even by our own AID, until improved environmental procedures used by that agency led it to refuse assistance and to seek alternative types of development. Some of the largest of these settlement projects are quite recent, or are continuing to be funded to this day, such as Caquetá in Colombia (World Bank), Polonoroeste in Brazil (World Bank), Central Selva in Peru (Inter-American

Development Bank), and Indonesia Transmigration (World Bank). This is so, despite evidence that agricultural yields are unlikely to justify the projects, and that the project sponsors can not recommend successful crops or techniques to the smallholder settlers.

Tropical forests are too valuable to waste in such a manner. If some of them must be cut, to support millions of landless poor people, it is crucial that the result be sustainable prosperity for the settlers, in order to minimize the amount of remaining forest that must be destroyed. It is this goal of sustainable development in agriculture that we are here to discuss.

Other witnesses appearing today will describe in some detail a few of the projects and types of development that have been particularly destructive. I would like to concentrate on what steps are needed to move in a more positive and productive direction.

As you are probably aware, the Federation, along with other conservation organizations, notably the Natural Resources Defense Council and Environmental Policy Institute, have been engaged in a campaign over the last year-and-a-half to raise these issues and others with the multi-lateral development banks (MDBs) such as the World Bank and the Inter-American Development Bank, and with the U.S. Treasury Department. We seek to have the MDBs include environmental planning in all their development projects and programs from the earliest stages of conception and design.

And we have asked the Treasury Department, which handles U.S. communications with the banks, to promote this message forcefully.

Since the spring of 1983, much progress has been made. During five days of hearings before the House Subcommittee on International Development Institutions and Finance, the issues of the environmental, social, and health impacts of many MDB projects have been examined in detail. The Subcommittee recently has drafted a set of recommendations for changes in how these issues are handled by the banks. The Treasury Department has indicated that, in its view, most of the recommendations are reasonable. Meanwhile, the World Bank has issued a binding policy and procedure statement, for the first time outlining the Bank's requirements for assessing environmental aspects of development projects.

But as we have stated in testimony before the Banking Subcommittee, and to the Treasury and MDBs directly, our goal is improved projects, not just improved procedures. We are looking for a major commitment from the MDBs and the bilateral aid agencies to projects that foster sustainable development. Some project ideas can be recommended now, but for the most part, research is needed to find better alternatives for the tropics.

Agriculture is a case in point. It seems clear that special solutions are needed to provide sound systems of agriculture suitable for tropical forest zones. For example, research currently indicates that tree crops rather than annual crops are more likely to succeed, because trees are best suited to these soils and the climate. But preliminary results from the Jari

Plantation in Brazil suggest that even with tree crops, if the vegetation is removed, rather than recycled, production goes down in the second generation of trees. Results from temperate forestry research are generally not appropriate or useful for predicting success under tropical conditions.

Similarly, monocultures, which are vulnerable to pest outbreaks under the best of conditions, are particularly unsuited to tropical regions. The number and variety of pests are higher in warm climates, and at the same time developing countries are less able to afford pesticides than industrial nations. Research results indicate that diversity of crops, particularly dense intercropping, and other aspects of integrated pest management, show promise of low-cost protection from pests.

Therefore, the single crop consultants and extension advisers, often from industrial countries, commonly hired by development agencies to manage agriculture projects, generally are not appropriate experts. Most of the agriculture projects which affect tropical forests involve the settling of landless families on small plots, or the consolidation of scattered settlements of spontaneous colonists who have claimed small land holdings. What is needed is extension expertise to deal with the diverse needs of the small farm, including tree crops, intercropped annuals, and domestic animals. Serious research efforts should be devoted to the small-scale, diversified, low input, and labor-intensive systems that most settlers will have to practice, at least for the foreseeable future.

Up to now, most agriculture research has been dominated by the land grant universities in this country, and the thirteen international agricultural research centers under the Consultative Group on International Agricultural Research (CGIAR). The latter organization now receives a considerable portion of its funds from the World Bank. It was started by the Rockefeller and Ford Foundations, and its research centers spearheaded the Green Revolution. The breakthroughs which produced the new high-yielding varieties of wheat and rice, which have raised production in many parts of the world, have also resulted in considerable controversy over equitable distribution of food, credit opportunities, and profits, as well as ecological threats such as widespread pesticide contamination. Regardless of the success of these new varieties where they have been introduced, the fact remains that millions of small farmers cannot use them (for lack of funds, transportation, or other reasons). Moreover, suitable high-yielding varieties of corn are not available, so corn growers, particularly in Latin America, receive no benefit, in any event.

Instead of trying to import inappropriate crops and techniques from temperate climates and to use mechanized agricultural systems, those research institutions interested in developing countries should concentrate on appropriate crops, cultural methods, and tools for the small-scale farmer.

One of the most promising avenues is the field of agro-forestry, in which tree and annual crops are grown together. Several different kinds of systems have been found suitable for

humid or dry tropical regions, different altitude and soil conditions. Pilot projects have already been proven successful, but site-specific research is needed before embarking on each new project in different terrain. Although some work has been done in this area, high priority should be given to a major effort by the principal research and funding institutions.

A promising variant of agro-forestry, called the Chinampa, deserves particular attention. Chinampas were used by ancient Maya peoples in Central America. They involved drainage canals, raised beds between the canals, intercropping of annual crops with trees, other trees used to stabilize bank edges, green manure from the canal bottoms for fertilizer, and fish culture in the canals. Such intensive and productive use of land permitted a large population to be supported for long periods on limited land; perhaps it or a variant could be useful again today. But whether or not this system can be widely adopted, the key is to find ways to support increasing numbers of people on land that is already being used, in order to reduce the pressure on remaining primary tropical forest.

Another important but neglected avenue for research is the sustainable use of the products of the existing forest. For example, certain nut trees may produce a crop equal in value to the total yield of row crops that would be produced if the forest were cleared. Similarly, the standing forest may produce medicinal plants, rubber, small animals for food, and selected trees for timber, all without destroying the forest ecosystem.

Conclusion

The current rapid rates of tropical deforestation are the result of many factors, including the demand for timber and beef in industrialized countries. But one of the major causes is the expansion of agriculture from both planned settlements and spontaneous colonization. The pressure caused by this expansion could be reduced significantly if promising research leads in agro-forestry, and other appropriate small-scale agriculture technologies, were successfully implemented. The key actors in filling the present knowledge gap would be the CGIAR and U.S. land grant agricultural research establishments, with funding from the bilateral and multi-lateral development agencies. These institutions have not concentrated on sustainable technologies for the small farmer until now, and they may be reluctant to devote significant resources to such a different approach. But a major effort is needed.

The National Wildlife Federation urges you to expand upon this first hearing and to continue your investigation into the significant gaps in research needed for sustainable agriculture. Strong recommendations from this Subcommittee would be persuasive in shifting research priorities toward more appropriate agricultural development.

Mr. SCHEUER. Thank you for your excellent statement.

You say that this is not an isolated day of hearings. This hearing itself is building on a hearing that we had, what, a year or so ago, on the need for more appropriate research patterns among our agricultural research institutions, the need—in reference to their appropriateness for Third World countries. We particularly—we had many witnesses talking about discussing the need for new seeds, new plants, that were drought resistant, that were heat resistant, that were blight resistant, that were flood resistant, and that did not require large inputs of fertilizer—and, of course, if they're drought resistant, they wouldn't require large inputs of irrigation—both fertilizer and irrigation being extremely capital intensive and extremely energy intensive, two components that are desperately scarce in the developing world. So you've hit a very sensitive nerve with us, all of you have.

I'm going to ask you—I'm not going to propound this question just for Mr. Lutzenberger. I'm going to ask Mr. Lutzenberger and all of you, in effect, to answer the question that Mr. Millikan phrased probably better than I'll be able to phrase it. But, in any event, the question of the implication to U.S. agricultural research policy toward Third World agricultural development, the kind of research policies that we should be following that are not entirely dependent on U.S. high technology, agricultural systems, and that are more dependent upon labor intensive processes and systems, as you suggested, Miss Bramble, and on policies that harmonize better with available resources, that don't require large inputs of energy and capital, that depend on human capital which is abundant in most Third World countries, and that contemplate the kind of agricultural and food production design that is in harmony with the environment, particularly the rain forest environment, which has survived as a miracle of heterogeneity and diversity for over the millennium.

Do you want to rephrase your question? Perhaps you can do it in a sentence, Mr. Millikan. One sentence.

Mr. MILLIKAN. I think you said it quite well.

Mr. SCHEUER. All right. I'll accept that.

Mr. MILLIKAN. I think—how can agricultural research—and I think it has implications in terms of development policies as well—but where are the kinds of areas in agricultural research where the United States could be promoting I think both the needs of the small farmer and a type of agriculture which is adapted to the environmental characteristics, those particular ecological characteristics of the region?

And I think another aspect of the question is identifying regions where that is possible and regions where it is not possible, such as areas where these kind of intense migration rates, because of social problems in other areas of the country, will make that probably impossible. And I think also another aspect of the question would be how can existing social—or how can existing research institutions in these developing countries change their priorities more toward these needs and the need for development agencies to recognize that probably those priorities don't exist right now.

Mr. SCHEUER. Very good.

All right. Now I'm going to propound two questions, and I'm going to give them to you right now, so that as each of you are talking others can be thinking about two aspects of this whole discussion, this fascinating discussion we've heard this morning that particularly intrigued me.

What we have seen here in this Polonoroeste is a process that ran awry, that strayed far from its intended purposes. How can we set up an institutional mechanism that would avoid that? Should the—should the World Bank and other multilateral development institutions and lending agencies develop some kind of environmental or ecological impact statement that they would do—that they would perform periodically, let's say every couple of years, over the course of these 10- or 20-year projects, so that instead of waking up 10 years after the project has taken place and seeing vast areas of invaluable forest land and rain forests have been irretrievably and irremediably devastated, we would begin to learn of the consequences of this, of this machinery that we have let loose far earlier in the process, and perhaps be able to remediate the system and recast the basic philosophy of these projects in process.

We do this—we have in our oversight of our own domestic programs in the Defense Department and many other programs, we have intermediate points where we look at a project, evaluate it, and see if it's reflecting its original purposes, and whether for some reason it has run amuck. Should there be some kind of an intermediate impact statement process built into the design of these projects, perhaps by our AID Program, if that isn't adequate now, and perhaps by the World Bank and other funding agencies. That's my first question.

The second question is a very sensitive question, and that comes from the repeated suggestions we have had this morning that we should really be telling the Government of Brazil how to use their resources. This is a very sensitive question between the haves and the have-nots, between the north and the south, between the developed, industrialized world and the developing world.

I've been around the developing world a lot in the last 20 years, and as I have expressed environmental concerns, I constantly get the feedback:

Look, we're not as worried about the environment as you are, and if we are, we're worried about different—we put that environment label on different phenomena. You people in the industrialized west raped the planet over the past couple of centuries; you only got so-called environment religion in the last generation, perhaps after World War II, but before that you were wreaking havoc that we're still paying for. And now you've gotten religion in your post-industrial era and you're asking us to get that religion before we've even begun to enjoy the benefits of industrialization such as you have. Yes, you have your smokey skies and your dirty water, but you've had the benefits, too. Our environmental problems are disease, illiteracy, filth, ignorance, high rates of maternal and infant mortality and appalling poverty. Those are our environmental problems. And until we solve them, we can't be as concerned with the long-run problems as you are.

And that was very clearly illustrated in the film, where the Brazilian Government employee said: Look, we have to feed people

today. We hope that over the long pull these land areas can be made productive. If they aren't productive, we'll have to have a reevaluation some time in the future. But today our problem is desperately poor people who we have to fill.

How far do we have the right to go in terms of cultural imperialism, the so-called arrogance of the north of the developed west, how far do we have to go—how far do we have the right to go, to tell a country like Brazil, here's the way you must use your natural resources; you can't clear that land and use it for the benefit of raising food and giving jobs to poor people; you've got to put these long-term environmental concerns ahead of the urgent, desperate needs that you have as a government to take care of the welfare, to do something about the welfare of your people now.

This is something that has to bother all of you, it does bother me. What do you have to say about both of these things?

We're running desperately late—this is off the record. Please keep your answers to a couple—a minute or two or three at the most, and then we'll finish the hearing.

Mr. LUTZENBERGER. I have a——

Mr. SCHEUER. All right. We'll go from left to right. We'll hear from Mr. Lutzenberger first, and then we'll work our way across the table.

And I would ask you to submit your answers to the first question that Mr. Millikan and I propounded sort of together, submit those answers in writing, and they will be made a part of the record.

Mr. LUTZENBERGER. Well, I would like to answer the second question concerning cultural imperialism. Well, this argument usually comes from our powerful, and what they do not say when they argue that they have to solve the problems of misery, of famine and so on, first of what they often call the pollution of poverty, is that—"pollution of poverty" is a word they use very much in Brazil—is that they are causing that pollution of poverty. It's the powerful of today who concentrate the land and concentrate technocratical power and destroy the capability of the simple man to help himself. They are causing that pollution, and then they invent ways out, like this settlement scheme in Rondonia. So there is a lot of cynicism in this argument, too.

And I think, putting myself in your place, of course the United States cannot tell our Government what to do. But it can certainly avoid helping the schemes that are pernicious.

Mr. SCHEUER. Thank you.

Moving across.

Mr. MILLIKAN. In terms of the first question concerning priorities of agricultural research, I will pretty much restate what I said before, which is that I think the World Bank and other development agencies need to recognize the importance of these priorities, but at the same time the contrast that exists between these types of environmental and social priorities and the existing patterns of agricultural research in overall agricultural development policy which gets into very many areas, which are the current priorities of these developing countries.

At the same time I think the World Bank needs to evaluate its own environmental impact evaluation in terms of how can the projects which it's promoting be realistically implemented in terms

of environmental priorities, and whether there really is a possibility for those kind of priorities to be carried out.

Second, your other question concerning the process of development and environmental issues in developing countries, I agree completely with Mr. Lutzenberger's statement, which is that the current process of agricultural development really is not in the benefit of the vast majority of the people or of the environment. In states such as Parana, the "green revolution" type of agriculture has resulted in areas where you have 144 tons of erosion per year of topsoil because of this kind of imported agriculture. At the same time it's not benefiting the people.

So I think it's almost an artificial question. One needs to ask: Who is being benefited by development? I think it ultimately becomes a question of process of development which benefits neither the majority or the majority of the country's rural poor, or ecological sustainability is also not a priority.

Mr. SCHEUER. Thank you.

Do you have anything to add, Miss Bramble?

Ms. BRAMBLE. Just a couple of brief points.

In terms of your last question first, of the cultural imperialism, I've been worried about that problem myself for quite some time, listening to the statements and the private conversations of government leaders and nongovernment leaders from—nongovernment organization leaders—from other countries. And I think if you separate out the kinds of environmental problems we're talking about into the more advanced types—the toxic wastes and the pollution problems, which we are so concerned with now and which, of course, are the problems of affluence—and the different kinds that we've been talking about today, of soil management and basic resource management, that, in fact, is the only way they're going to have the development that they want, you will see an incredible difference.

And over the last 10 years the growth and sophistication of understanding in most of these countries is likewise quite extraordinary. You will not so often now, I believe, hear someone denegrading concern about that latter group, the resource issues, instead saying "We need to develop first," because they know you can't do it that way. If they were to wait for a time when they were affluent in order to deal with their basic agriculture resources, there would be no such time, and I think that is very well known now. It's taken a while.

Briefly, with regard to your middle question having to do with the assessment, some midterm assessment of—by the development institutions, I think it would be an incredibly important change if such assessments were done on a regular basis. I think there is some understanding of the need to do that. And, in fact, in the Polonoroeste project there are several people who have been looking into the current status of that project. But there's not an institutionalized way to bring that to the attention of decisionmakers who might have something to do with how the rest of the project is going to be completed, if it is. And while there are plenty of conscientious people who know that things are not going well and that they should be pulling out of that project, there's certainly no public way—there isn't any regular involvement by, for instance,

the Executive Director representing the United States to get at that. But there's——

Mr. SCHEUER. By whom?

Ms. BRAMBLE. The Executive Director representing the United States, who could bring this issue to the attention of the World Bank.

Mr. SCHEUER. The executive director of what? I didn't quite get that.

Ms. BRAMBLE. On the Board of Directors of each of the banks there are representatives of each of the major donor countries——

Mr. SCHEUER. Yeah.

Ms. BRAMBLE [continuing]. And the United States has one, and his vote was important, of course, in approving the project in the first place.

Mr. SCHEUER. Right.

Ms. BRAMBLE. Bringing this to the attention of those officials would be useful, but I think more important is that it be regularized, as you have suggested.

Mr. SCHEUER. Right. Mr. Rich.

Mr. RICH. Mr. Scheuer, concerning your second question first, first of all I would heartily second what Mr. Lutzenberger has said. I would like to say that we often forget that in the developing world a lot of progress has been made in the last decade concerning environmental awareness and institutionalization of environmental concerns.

In 1972, at the time of the Stockholm Conference on the Human Environment, there were only about a dozen countries in the world which had environmental ministries and really a substantial environmental legislation. Now you have over 110 countries. You also have the growth of the nongovernmental environmental movement in the developing world.

So what is really happening is that the—oftentimes representatives of the major development agencies simply aren't talking to these people. When projects are planned, the representatives of these new ministries of environment in the developing world just aren't consulted. So it's not a matter of telling the governments what to do; it's a matter of involving broader based participation in the planning of these projects.

Concerning what the—how we can improve the environmental performance of these development agencies, and especially the multilateral banks, which are by far the most significant actors in Latin America, again I think the way to go about this is through, at least for the United States, is through the Treasury Department which can direct the U.S. Executive Directors of the World Bank and Inter-American Bank to promote improved research and improved environmental planning and procedures within the banks.

I would like to conclude with one example. The World Bank has a centrally funded research program of $25 million a year. In 1983 it had 122 ongoing projects, and not—research projects—and not a single one of these projects was even remotely concerned with sustainable management of natural resources. That's something that could be—changes in the research program of the World Bank—could be promoted immediately through the U.S. Executive Director.

Mr. SCHEUER. Very good.

Mr. Illueca.

Mr. ILLUECA. Concerning your first question—concerning your first question on the necessity for ongoing environmental assessment of projects in development, we consider this to be one of the most crucial areas that have to be improved. What too often happens with a loan by the World Bank is that, whereas the economic aspects of the loan will be audited during the progress of the loan, too often the environmental impact assessment that was required for the development of the project is the end of whatever environmental impact assessment or evaluation is made.

I'd like to address a specific example of a project that was funded by AID in Panama that failed in evaluating environmentally the project as it was in progress, and consequently a large amount of funds really were not efficiently utilized. AID, as I mentioned before, has participated in a multimillion-dollar project for the institutional strengthening of certain institutions involved in environmental management. In one such project, which required not only the development of the human resources within the institution, $3½ million were earmarked for reforestation projects over a period of 5 years. All right, the $3½ million were utilized that were contributed by AID, plus approximately $1½ that came from the Panamanian Government. And it wasn't until after 5 years after initiation of the project that the first evaluation was done on the success of that reforestation project. The result or the conclusion was that the project had not been cost effective, that there had been tremendous problems.

But, in this situation, they waited until 5 years had passed. The funds had been utilized and to a great extent the project ended up in producing some very serious problems in terms of institutional organization in the country.

One of the specific recommendations that is presented in my report is that offices within these multilateral lending institutions have to have a very, very direct role, not only in developing an environmental data bank as keys for assessing the ecological soundness of proposed projects, but also to encourage research, to constantly provide the project developers with information and assessment.

Concerning the second question on cultural imperialism, the issue is a mute one, I feel, in the case of Panama, in the sense that the orientation that is being given in Panama is for the development of projects that can be sustained over a long period based on the sound management of natural resources. What I do think that is key here is not so much going down and telling a country, "Here, you have to put these forests aside and those forests," because although it's important for the countries themselves to set up their national parks and their biological reserves, those same countries are faced with growing population, with unemployment, with meeting the basic needs of their population.

What has to be done is promote environmental management projects that are going to not only contribute to the protection and management of the environment but are going to create jobs. The Inter-American Development Bank, for about 5 years, has been considering a massive reforestation program in Panama utilizing

commercial species that could be concentrated in the watershed of the canal, so that you would be meeting a variety of different economic and environmental objectives. You would be protecting the actual operation of the Panama Canal, which is basic for the Panamanian economy. Second, you would be creating labor-intensive activities in terms of employing people for the actual reforestation p[illegible]ess. Third, you would be reforesting certain areas with com[illegible]cial species that could contribute to a more positive balance of trade.

I think it's extremely important that a strong emphasis has to be given by the multilateral development banks to reforestation and forest management projects that have some very, very strong economic objectives.

A last point I want to make is that our experience has been that, if a development project is designed from the beginning coordinating well the environmental and the economic objectives, it is much easier to develop projects that are environmentally sound. We're currently working on two projects, one which is for the development of a sanitary landfill system for the city of Panama, and two, relating with alternatives for a new canal, in which the environmental impact studies are being conducted jointly with the engineering studies. This is one thing that we have insisted, that has been a failure in many environmental impact studies in Latin America, that you'll have one team working over here on the environment, and you'll have a second team working over here on the development of the project.

When they complete their studies, there hasn't been a convergence. You end up having a conflict between the two. But if you begin the two working initially—as a matter of fact, many of the engineering studies require some of the basic studies that are necessary for the environmental impact studies.

In the case of the sanitary landfill project in Panama, geological perforations are needed for the environmental impact assessment as well as for the engineering studies. So the whole point is that you have to have that coordination come from the beginning and not at the conclusion of the project.

Mr. SCHEUER. Thank you very, very much.

This has been a remarkably interesting panel. We have run way over time, and that's testimony to the fact that we didn't have the heart to terminate the testimony. We are grateful to you all.

If you have any further thoughts that you would like to have included as part of the printed record, please write them to us. We'll hold the record open for 10 or 12 days, especially for your comments on the first question about suggested redirection of agricultural research in the United States and any other comments you may have additionally on the questions that I raised in my last few moments.

Thank you all for a very stimulating, very knowledgeable session here this morning. The meeting is adjourned.

[Whereupon, at 12:50 p.m., the subcommittee was adjourned.]

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APPENDIX

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220

ASSISTANT SECRETARY

October 22, 1984

Dear Mr. Chairman:

Thank you for your letter of August 30, inviting the Treasury Department to present its views to your Subcommittee.

Even though an appropriate official could not be made available to appear before your Subcommittee at the time, the Subcommittee staff indicated that it would be useful to have information regarding the extent to which agricultural research is used in multilateral development bank (MDB) projects and the extent to which such projects might be vehicles for conducting research. The staff asked that the Northwest Brazil development program be included in our submission to the Subcommittee.

MDB projects are designed to support the development of borrowing countries. There is no general rule that mandates or precludes research components in such projects. As a practical matter, most agricultural or regional development projects include applied research components of greater or lesser significance. Almost invariably, such research is designed to provide information directly to agricultural extension services and, then, the individual farmers.

The Northwest Brazil regional development projects are somewhat unusual in the range and depth of their research activities. The enclosed paper, which is based on IBRD documents, discusses the program in some detail.

I hope you will find this information helpful. If I can be of further assistance, please do not hesitate to ask.

Sincerely,

Bruce E. Thompson, Jr.
Assistant Secretary
(Legislative Affairs)

The Honorable
James H. Scheuer
Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment
U.S. House of Representatives
Washington, D.C. 20515

Enclosure

IBRD Support for Development in Northwest Brazil

1. The Physical Setting

The Northwest region of Brazil is officially defined as the area of influence of the 1500 kilometer Cuiaba-Porto Velho road, or Brazil Highway Numbers 70, 174 and 364. The area comprises all of the state of Rondonia, plus fourteen municipios (equivalent to counties in the United States) of the central and western parts of the state of Mato Grosso.

In total, the Northwest covers approximately 410,000 square kilometers or slightly less than five percent of Brazil, but about three-quarters the size of France. The regional population was estimated in the neighborhood of 1,000,000 in 1980 and had been growing at 10.8 percent per year during the previous decade.

The dominant physical feature of the region is the east-west oriented ridge of the Serra Dos Parecis (elevation about 600 meters), continued in Rondonia by the Serra Dos Pacaas Novos. The ridge line separates the watershed of the River Plate Basin to the south and the Amazon Basin to the north.

The natural landscape of Rondonia is of virtually uninterrupted tropical moist forest giving way to grasslands and swamps to the southwest. In the region north of the Serra Dos Pacaas Novas, rainfall is near or exceeds 2,000 millimeters annually.

The landscape in Mato Grosso starts with tropical forest in the west and gradually shifts to savannah, or "cerrado," in the east, with the seasonally flooded Pantanal in the southeast. Rainfall is about 1600 mm in the north of the state, tapering some to 1200 mm in the southeast.

2. The Brazilian Approach to Development in the Region

While relatively short-lived economic booms (based on gold in Mato Grosso and on wild rubber in Rondonia) have lured migrants in the past, most of the present population arrived after the opening of the Cuiaba-Porto Velho highway in the mid-1960s.

The Northwest has been perceived in Brazil -- not entirely accurately -- as a region of rich soils and great economic potential, a perception sometimes promoted through media advertisements sponsored by government agencies. To the government, the region has been viewed as an important future source of agricultural production for export and for domestic consumption, as well as a location where migrants from other parts of Brazil can be productively and permanently settled on small-scale farms. To private firms, the region is viewed in terms of the gain arising from agriculture, livestock, forestry, mining, light industry and land development. While public and private objectives can complement each other, the disorderly development of the past has suggested the need for promoting rational land and resource use patterns, if expectations are to have a chance of being met.

To achieve such use patterns, the Brazilian Government promulgated an Integrated Development Program for the region in 1980 (known by its Portuguese acronym, POLONOROESTE). With the 1500 km Cuiaba-Porto Velho road at its core, the Program called for land settlement, agricultural development, environmental protection, support for Indian communities and feeder roads. The Program was to be implemented during the following decade in three phases, with World Bank planning and financial participation in each phase.

3. The Northwest Regional Development Projects

Phase I consisted of three simultaneously launched projects. The $687 million highway paving project included a $240 million loan from the IBRD. The $199 million agricultural development and environmental protection project was partially financed by a $67 million IBRD loan. The $38 million regional health project was funded, in part, by a $13 million IBRD loan. These IBRD loans were effective simultaneously on December 1, 1981. These loans were elements of a comprehensive project plan where the success of one element relied on performance in each of the other elements.

The highway project was designed to upgrade, including paving, 1,084 km of the Cuiaba-Porto Velho highway (with the Brazilian army responsible for reconstructing and paving the remaining 355 km). The project also provided for supporting highway operations through construction of a weigh station and other civil works and through equipment of a highway patrol and evaluation service. In addition, the project provided infrastructure, equipment and training to strengthen the Rondonia state highway department. Finally, the project supported the construction of 500 km of feeder roads in Rondonia and 488 km in Mato Grosso.

The agricultural development and environmental protection project, while monetarily smaller, was significantly more complex. The Rondonia settlement consolidation component was to establish 39 rural service centers to provide economic services (credit, marketing, extension and inputs) and social services (education, religious and health) to approximately 7000 rural families. The environmental protection and ecological research component was designed to: (a) strengthen the national forestry agency (known as "IBDF"), (b) finance infrastructure and surveillance of three national parks, (c) support planning for national forests, (d) set up four ecological stations, and (e) conduct basic research on the environment. Finally, the project was to conduct land surveys and soil testing in other areas of the region in preparation of the next project phases.

The health project was designed primarily to intensify malaria control activities. In addition, the project was to establish a health center in each of the 39 regional service centers, 50 decentralized health posts and 3 health referral centers in medium sized cities of Rondonia. Training, health research and program evaluation were included in the project.

Phase II was a $77 million integrated project, of which the IBRD supplied $26 million. The project was to serve 17,500 small farm families in Mato Grosso through economic services (extension, inputs, road improvement and infrastructure) and social services (education, health and water supply). In addition, the project provided for land zoning based on agricultural and ecological conditions. The IBRD loan was effective on March 25, 1982.

Phase III was a $182 million project, including an IBRD loan of $65 million. The project was designed to manage 1.1 million ha of undeveloped lands in Rondonia and consisted of: (a) land use planning, (b) rural road construction, (c) construction of seven rural service centers, (d) associated economic and social services, (e) pilot forestry enterprises and forest protection activities, and (f) studies for further projects in Rondonia and Mato Grosso. The IBRD loan was effective on October 25, 1983.

On December 8, 1983, a sixth IBRD loan for the POLONOROESTE program became effective. The $22.8 million loan was designed to maintain implementation of the Phase I agricultural development and environmental protection project and, more broadly, to assist Brazil in a particularly difficult period of economic stabilization.

4. The Environmental Considerations and Research Elements

The preceding description of the three initial phases ot the POLONOROESTE is based on the original design of the Development Program for the region. The Program sought to address explicitly four inter-related environmental considerations through research and practical implementation measures: (1) abundant water resources in the context of generally poor quality soils, (2) the biological diversity in the region, (3) human health considerations and (4) protection of culturally distinct American Indian populations.

a. Water and Soil

In view of the drought that has afflicted other agricultural regions of Brazil, the generous and dependable availability of water in the Northwest region is certainly one of the most alluring elements of the POLONOROESTE program. In all areas, there is a single summer rainy season increasing from five months duration (November-March) in parts of Mato Grosso to seven (October-April) in Rondonia. The rains open and close with a month of intermediate rainfall, leaving a dry season of five months (March-September) in southern Mato Grosso and three months (June-August) in Rondonia.

Frustrating the vision spawned by this ample supply of water --and veiled by the illusion engendered by lush vegetation -- is the predominance of soils very poorly suited to sustained agricultural use. The high rainfall has, itself, leached essential nutrients, leaving behind soils poor in phosphorus, calcium and nitrogen and laden with toxic aluminum. Such nutrients as exist are in the lush vegetation itself. When leaves and branches fall, nutrients are quickly absorbed again into the living system by the relentless action of water, microbial decay and the efficient, extensive root system of all forms of plant life.

Despite the general poverty of the soils, the extensive river system and its rhythm of seasonal floods have deposited plant nourishing minerals, washed down from surrounding mountain ranges. These numerous, scattered tracts of fertile land can sustain annual crops common in other parts of Brazil, such as rice, beans or corn.

The extent and location of agriculturally useful soils has been uncertain. For example, a 1980 World Bank report classified Rondonia soils according to agricultural utility based on a 1:5,000,000, 1975 soil survey conducted by the Brazilian Agricultural Research Enterprise (known as "EMBRAPA"). The 1981 Phase I agricultural appraisal report similarly classified Rondonia soils based on a 1:1,000,000 RADAM BRASIL survey of uncertain date. The estimates were notably different. The apportionment of the state's 234,000 square km are contrasted below:

Agricultural Utility (%):	1980	1981
Good	1.6	9.9
Moderate	78.9	60.9
Marginal	0	7.4
Unsuitable	19.5	22.7

Apart from the variability in the estimates (which may, in part, reflect slight variations in the meaning of "good," "moderate," etc.), two points are important.

First, for soil surveys for agricultural land use and zoning purposes, normally a greater fineness than 1:5,000,000 or 1:1,000,000 is desirable. At the time of Phase I project approval in 1981 project connected research was intended to include much finer soil surveys for the areas identified for settlement.

Second, the middling "moderate" category explicitly envisioned declining yields after a few years of use in the absence of significant levels of fertilizer application. Even neglecting the poverty of the region's farmers, the cost of transporting petroleum based fertilizers into the area is very high.

The uncertainty regarding the extent of usable soils and the need to adapt agricultural production to soils of lesser quality lies at the core of extensive agricultural research efforts in all three phases of the project thus far. The 1980 IBRD report on the POLONOROESTE Program called for a 1:250,000 land suitability survey for all unoccupied areas considered likely to contain soils which had potential for agriculture and which were not already allocated to other purposes, such as national parks. Within identified agricultural zones, land suitability surveys were to be done at scales ranging from 1:250,000 to 1:100,000 depending on the potential intensity of land use. The report anticipated, as well, the need for expanded crop, livestock and plant disease research.

Noting separate national research efforts for such important perennial crops such as rubber and cocoa, the 1981 appraisal report for the Phase I agricultural development project in Rondonia was oriented to the short-term research needs of the settlers in the project area, at an estimated cost of $4.4 million. Research was to concentrate on the adaptation of the main annual crops (corn, rice and beans) to conditions in the newly opened areas, and also on farming system research to be initiated with a view to collect, as early as possible, more information about the optimal crop mixture for small and medium farms. At least half of the experiments were to take place at farm level.

Specifically, provisions were to be made for the establishment of (a) three demonstration farms, including perennial crops and livestock; (b) three experimental substations, each of 10 ha, to test new cultivars; (c) three simple weather observation stations located at EMBRAPA research stations; and (d) soil test and mapping services to support an improved land use policy and to provide the local extension service with the required information to train officers in proper land use practices (including crop rotation) and erosion and environmental control.

The Phase II 1982 projects in Mato Grosso was: (a) to continue the efforts to identify and to establish zones based on the natural resource potential of the area; and (b) to select and adapt crop varieties and cultivation techniques to the logistical and ecological conditions in the project area.

The research and zoning component of the Phase II project was to cost $1.2 million and was to include: (a) soils and agriculture aptitude surveys of 55,000 square km, covering the most diverse portions of the project area and the southern portion of the Guapore Valley (the possible future site of settlement projects) at a scale of 1:250,000, to be performed by EMBRAPA and (b) equipment and services to strengthen the state agricultural research agency. The state agency was to: (a) collect, update and analyze available data on climate, hydrology, topography, cultivation practices, soil properties and local flora and fauna; (b) conduct studies and produce maps of a scale not smaller than 1:50,000, representative of special soil or ecological conditions, including such soil capabilities as water retention, and other physical and chemical characteristics; and (c) prepare municipio maps to a scale of 1:100,000.

The adaptive research component of the Phase II project was estimated to cost $4.4 million which would finance: (a) construction and equipment costs for 10 field posts of varied size; (b) expansion of headquarters management spaces in Cuiaba; (c) salaries and operating costs for 70 additional staff members for the state agricultural research agency; and (d) thirteen man-months of technical assistance. These resources were to be used to strengthen research for the forested western areas of Mato Grosso, including some 55 crop experiments in each of three municipios with later field testing on six private farms. In addition, some 115 tests were to be made on other farm level plots.

The research component of the Phase III project in Rondonia was budgeted at $2.1 million to have EMBRAPA: (a) establish and operate an experimental sub-station in the settlement area; (b) establish and provide supplies for 150 farmer-operated fruit tree and annual crop demonstration plots; and (c) strengthen the soil and leaf analysis capacity of Porto Velho station. Research was to include investigation into areas such as locally appropriate crop rotations; diversification of farming systems; and farm management.

b. Biological Diversity in the Amazon Region.

The Amazon holds the world's largest tropical evergreen rainforest and most diverse biological stock. Many species of its plant and animal life are as yet unidentified, with unknown possible value to human beings. This fact highlights the importance of basic biological research and argues for the maintenance of large biological reserves in various places in Amazonia, since the stock of flora and fauna varies greatly from one sub-region to another.

The major institution responsible for carrying out national forestry policies is the National Institute for Forestry Development ("IBDF"). Of particular importance for accruing the benefits of biological diversity in the Northwest region, IBDF bears the primary responsibility in the federal government for conservation, national parks, forest reserves and general forest development. The main tracts in the Northwest are:

-- the Pacaas Novos National Park in Rondonia created in 1979 and encompassing 764,800 ha,

-- the Guapore Biological Reserve in Rondonia, awaiting creation with 500,000 ha,

-- the 679,000 ha Jaru Biological Reserve in Rondonia created in 1961, but since largely lost to a major cocoa project,

-- The Cara Cara Biological Reserve in Mato Grosso created in 1971, eventually to cover 80,000 ha on the Bolivian border. A proposed Pantanal National Park of about 250,000 ha would include this Reserve.

The Phase I agricultural development and environmental protection project included a comprehensive package of activities designed to obtain the benefit from the biological diversity of the Amazon forest at an estimated cost of $24.4 million. The project appraisal report envisioned the creation of national parks, biological reserves and national forests to maintain the ecological integrity of the region and to guarantee an adequate future supply of forest products and services for the domestic and international markets.

The report suggested, as an initial step, that the IBDF form a task force to identify areas suited for commercial operations. The next step would be to delineate those areas and to establish small teams of rangers, properly equipped, to protect these areas from invasions. Subsequent steps would involve detailed inventorying, management plans and appropriate infrastructure. At this stage, the four parks/reserves noted above were also to be strengthened or established.

Research facilities were to be strengthened through two existing and two proposed ecological research stations operated by the Ministry of the Interior and in which numerous academic institutions were to conduct research activities. The four stations are estimated to cover approximately 340,000 ha of diverse environments for field studies in Rondonia and Mato Grosso.

The report called for providing baseline ecological studies of the region as soon as possible to ensure early recognition of any negative effects from regional development. The three main lines of research activities were to be: (a) hydrometeorology and biogeochemical balances, (b) biological inventories and minimum ecosystem size studies, and (c) small scale alternative technology studies. The Brazilian National Research Council would be responsible for coordinating the studies.

c. Human Health Considerations

The 1980 IBRD report on the POLONOROESTE Program, citing the origins and age structure of migrants, suggested that demand for health services would be high. On the other hand, the absence of statistical information made it difficult to plan adequately for health needs. More importantly in identifying research needs, the process of deforestation and rapid settlement would cause changes in the environment which could increase the incidence of tropical diseases, such as malaria. Moreover, migrants could bring diseases, such as measles, influenza or tuberculosis, to which the American Indian population had no resistance.

The 1981 health project appraisal included $3.5 million to fund research, principally on malaria, to be coordinated by the Brazilian National Research Council. While not yet fixed, the research subjects were to supplement the efforts of the Tropical Disease Research program, and possibilities included:

-- the distribution and transmission potential of different anopheles vectors and mosquito biting patterns,

-- insecticide alternatives to DDT,

-- the cost-effectiveness of malaria control measures,

-- the chloroquine resistance of malaria parasites,

-- alternative anti-malaria drug treatments,

-- epidemiological research of disease patterns and research into leishmaniasis, and

-- snail foci for shistosomiasis transmission.

In addition, $90,000 was allocated to operate and maintain a malaria monitoring and evaluation system.

d. Protection of the American Indian Population

Since the colonial period, Brazil's American Indian population has fallen from an estimated two to five million to a present day population of less than 200,000. This dramatic decline has been the result of a combination of factors, including early slave raiding expeditions, exposure to disease and absorption into the dominant national culture through intermarriage. More recently, the progressive occupation and economic development of Amazonia has placed the American Indian population in an increasingly precarious position. Diseases transmitted by new settlers have decimated whole tribes and illegal seizures of American Indian lands have reduced the area available for traditional hunting, fishing and agricultural activities.

The 1981 agricultural development and environmental protection project appraisal report estimated that as many as 8,000 American Indians were living in the Northwest region, within 22 known tribal groups of different size, language, culture, and degree of acculturation to Brazilian society. Some had not yet been contacted by government authorities. About 4,600 American Indians lived in 5.3 million ha (13 percent of the region) which had been designated American Indian areas. Only a third of that area had been legally demarcated, and the presence of migrants had been a recurrent problem, with settlers occasionally clashing violently with members of the American Indian population.

The National Indian Foundation (known as "FUNAI") had established 26 posts in the region to protect the American Indian communities, although not all were fully staffed with administrative and health specialists. In addition to strengthening the FUNAI staffing and organization, the project sought to spur FUNAI to proceed with legally establishing protected Indian areas. Protection of Indian land rights is at the heart of FUNAI's role in the POLONOROESTE program. The American Indian project component was estimated to cost $26.6 million.

The appraisal report candidly stated that knowledge of the Northwest American Indians was still scarce, and information from different sources was sometimes contradictory. While not proposing specific research activities, the project -- by strengthening the agency primarily responsible for direct contact with the American Indian communities -- sought to encourage responsible and direct interaction by professionally trained and well motivated FUNAI officials. Improved knowledge and diminished misunderstanding would be an important by-product of successful implementation.

5. Current Status of POLONOROESTE Program

In 1981, the POLONOROESTE program was estimated to cost $1.6 billion with most of the funding to be provided by the Brazilian Government. The IBRD, in six separate loans (described in section 3, above), has committed $434.4 million to the Program. As of July 31, 1984, $178.3 million had been disbursed.

WORLD WILDLIFE FUND-U.S.

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September 25, 1984

The Honorable James H. Scheuer
United States House of Representatives
2402 Rayburn House Office Building
Washington, D.C. 20510

Dear Congressman Scheuer,

Thank you again for the opportunity to testify at the hearings this past week on the environmental impact of development bank agricultural projects. I think it was a very important and worthwhile exercise.

In response to your question as to how one avoids appearances of neoimperialism, I am happy to offer the experience of the World Wildlife Fund in this regard. A simple answer is to work as close as possible with citizens in the country involved so that they are the ones who are telling their government and countrymen how to modify their activities rather than having us, as outsiders, tell somebody else how to run their country. WWF has been particularly successful in pursuing this approach, which not only avoids the problems of antagonism, but, far more importantly, builds a cadre of concerned and effective people in the country, who will be there long after the World Wildlife Fund departs. We have, in fact, at the moment, through what one might term our educational subsidiary, a million dollar contract from AID to build the capacities of environmental organizations in Panama. A few more such projects on the part of AID could make an enormous difference.

I will look forward to a continuing dialogue with you and your staff on these critical issues.

With all best wishes,

Sincerely yours,

Thomas E. Lovejoy

TEL/dlb

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13 July 1984, Volume 225, Number 4658 SCIENCE

Amazon Basin: A System in Equilibrium

Eneas Salati and Peter B. Vose

Summary. Despite the very active deforestation of the last decade, the Amazon Basin is still primarily covered with trees and is a system in equilibrium. The Andes form a barrier at the western end of the basin and, coupled with the prevailing easterly winds, ensure an almost unique precipitation and water-recycling regime. On average 50 percent of the precipitation is recycled, and in some areas even more. The soils are poor. Most of the nitrogen and phosphorus is found in the soil, and the remaining nutrient elements are found in the standing biomass. There is some nutrient recycling and little loss from the intact ecosystem, and the small input of nutrients from precipitation maintains a small positive nutrient balance. Continued large-scale deforestation is likely to lead to increased erosion and water runoff with initial flooding in the lower Amazon, together with reduced evapotranspiration and ultimately reduced precipitation. Reduced precipitation in the Amazon could increase the tendency toward continentality and adversely affect climate and the present agriculture in south-central Brazil.

The Amazon Basin has an area of about 5.8×10^6 km^2 and drains about one-third of the land surface of South America (*1*). The main channel of the Amazon River, that is, Urubamba-Ucayali-Amazon, is some 6500 km long from source to mouth (*2*) and has about 1000 tributaries. Oltmann's estimate (*3*) of the mean discharge, confirmed by more recent measurements (1982 to 1984) (*4*), of 175,000 m^3 sec^{-1} or a total discharge of 5.5×10^{12} m^3 year^{-1} is five times that of the Congo and represents 15 to 20 percent of the global freshwater supply.

Deforestation in the Amazon Basin has accelerated in recent years, especially in the Rondonia, Acre, and Mato Grosso regions of Brazil (*5*). The major changes in land use, and the associated population influx, must inevitably affect the ecosystem. The large scale of the Amazon should not obscure the fact that it is presently a system in equilibrium. We discuss it here from the point of view of a system that has achieved a steady state in its water cycle, nutrients, and energy balance. We also consider the possible consequences of man-induced disequilibrium.

Water Cycle

The main influx of atmospheric water into the basin comes from the Northern Hemisphere trade winds. The Amazon climate is therefore characterized by mainly easterly winds. Rainfall ranges from 1500 to 3000 mm annually, averaging about 2000 mm in the central Amazon. In the eastern and western ends of the basin rains occur frequently throughout the year, whereas in the central part and in a portion of the western area of the basin there is a definite drier period. Here we must distinguish between the locally derived, relatively low cumulus clouds that seem to arise almost from the forest, and are initiated by latent and sensible heat (*6*), and the high-tropospheric clouds of the South American continent whose circulation, pattern, and influence on Amazon weather have recently been described by Kousky and Molion (*7*). The different rainfall regimes are determined by the interaction of the Intertropical Convergence Zone and the equatorial Atlantic air mass in the eastern region and by the presence of the equatorial continental air mass in the westernmost region. The rainfall regime of the central basin is determined by the expansion of the continental air mass in summer and by its contraction in winter.

Examination of aerial studies and Landsat imagery (*8*) has indicated no evidence of major north-south movements of water vapor within the basin, such as might be anticipated from the influx of air masses from the north. On the other hand, radiosonde studies (*9*) have indicated that some water vapor is exported south to Chaco Paraguaio and central Brazil, principally in March and December but to some extent in almost every month (*10*). Therefore, changes in the water regime of the Amazon Basin may have a direct effect on the rainfall of the Central Brazilian Plateau (*11*). It seems clear that the Andes form a natural barrier and prevent a major part of the water vapor from leaving the western end of the basin, as shown by the high levels (5000 mm) of precipitation in the Andean region.

In a situation where the horseshoe-shaped Amazon Basin experiences the main influx of water from the trade winds from the east and the apparent main efflux by way of the river to the east, major water-recycling effects might be anticipated through forest evapotranspiration. There is good agreement between evapotranspiration estimates obtained by more conventional climatological methods and those obtained by recent aerial and isotopic techniques.

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About 50 percent of the rainfall is evapotranspired as water vapor back into the atmosphere, of which about 48 percent falls again as rain (*8*, *12*, *13*). This mass of water returned to the atmosphere represents a very high recycling rate (*8*, *14*), with a mean recycling time of about 5.5 days (*15*).

Such figures are averages over large areas, including nonforested areas, and are also influenced by water vapor exports. More detailed watershed studies of loss by interception by the forest, transpiration, and evaporation, based on actual measurements of water gain and loss, indicate much greater evapotranspiration for the high forest. In two studies (*16*, *17*) carried out, near Manaus, which has just over 2000 mm of rainfall per year, it was found that 18.7 and 25.6 percent of the rain was intercepted by the forest and evaporated to the atmosphere, 62.0 and 48.5 percent was transpired by the forest, while runoff accounted for 19.3 and 25.9 percent, respectively, for the two locations (Fig. 1). Combined evaporation and transpiration therefore represented as much as 80.7 and 74.1 percent at the two sites (*16*, *17*). More intense rains resulted in greater throughfall.

Using measurements of the ^{18}O and D isotopes in rain and river waters, we found it possible to confirm (*8*, *18*) the importance of reevaporated water for the water balance throughout the basin, and in particular to establish a model indicating the relation with the new oceanic water. Consider that the central east-to-west region of the Amazon Basin between 0° and 5°S is subdivided into eight 3° segments between Belém (48°30′W) and just west of Benjamin Constant (72°30′W). A model can be developed (Fig. 2), which suggests that in any one segment about half the rainfall is derived from evapotranspiration recycling within the segment area, whereas the other half comes from water vapor derived from the neighboring eastern segment conveyed by prevailing winds.

For the most westerly, Andean, end of the basin we do not have good knowledge of the influx or efflux of water vapor, or indeed of recycling. The influence of Pacific Ocean–derived water vapor seems minimal, as shown by negligible concentrations of marine Cl^- in upper Amazon precipitation and river waters (*19*). Satellite photographs suggest an anticlockwise circulation of clouds northward over the Colombian part of the basin.

Large-scale deforestation, if continued at current rates, must inevitably affect the present equilibrium of the water cycle, and we have considered these effects elsewhere (*20*, *21*). It is now recognized (*22*) that clearing tropical forests reduces infiltration rates and generally increases runoff. Greatly reduced infiltration rates have been found to occur with clearance in Suriname (*23*) and in the Peruvian Amazon (*24*), especially when bulldozers are used to clear the land. Schubart reported (*25*) that on land derived from primary forest near Manaus infiltration rates of 5-year-old pasture were less than one-tenth of the rates for primary forest soil. Confirmation is obtained from other areas with a longer history of deforestation and conversion to agriculture. For example, in West Africa runoff from cultivated and bare soils was 20 or more times that from forest land (*26*). In Malaysia conversion of natural forest to rubber or oil palm doubled peak storm flows and halved low flows with greatly increased erosion. In one large catchment the low flows were reduced to one-quarter (*27*). The once major Motagua River in Guatemala is more than 50 percent reduced in volume, after the loss of 65 percent of the natural forests in the last 30 years (*28*).

An increase in peak flow associated with deforestation has been ascribed to the Peruvian upper Amazon by Gentry and López-Parodi (*29*), who found a statistically significant increase in the annual high water mark at Iquitos from 1962 to 1978. This conclusion has been disputed (*30*), primarily for reasons relating to the measurement base and the extreme variability. The problem of variability is a real one; for example, the historically high flood of 1953 occurred long before major deforestation was a factor. Nevertheless, the high annual floods experienced from 1970 onward and especially the high peak flows of 1981 and 1982, together with the commonly reported experience of riverside flooding, do suggest a direct connection with increased deforestation. Kempe noted (*31*) that the time of year of peak flow has shifted from May-June to June-July; he suggested that this is due to a higher mean annual discharge, which does not influence the peak flood level but causes the flood wave to shift.

Because the Penman equation (*32*) for estimating evapotranspiration can be applied to different vegetation types including, with slight modification, forest, it can lead to the belief that, when primary forest is replaced by some other type of vegetation such as pasture or annual crops, rainfall and the overall water balance of an area will not be changed. Hydrologists have been inclined to discount the possibility that changes in land

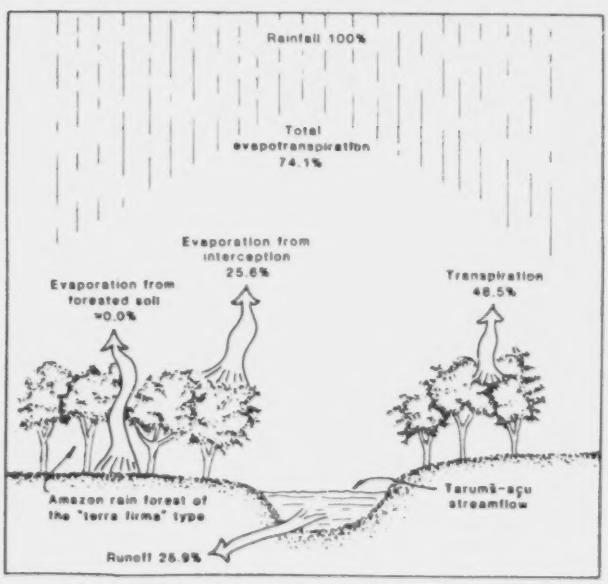

Fig. 1. Water balance from a study of a model basin near Manaus (*17*).

use can affect rainfall (*33*). This may be true if the area being converted is small in relation to the whole geographical-climatological zone and if the major proportion of the precipitation is advective and not dependent on recycling. However, it is almost certainly a fallacy where large amounts of water are being lost to the system through the greatly increased runoff associated with widespread deforestation and where the existing rainfall regime is greatly dependent on recycling.

Real loss of water from the Amazon water cycle is likely to be the major factor determining potentially adverse climatic change in this region. The forest canopy protects the forest floor from the direct impact of rain, and the surface debris and organic matter reduce runoff and ensure water absorption. The established vegetation increases percolation by maintaining a good soil structure, and both water recharge of the system and its release will take place relatively slowly. The disturbed soil will have reduced water absorption and shorter retention times than the forest soil it replaces. Salati and Ribeiro have reported (*11*) that deforestation will reduce the water residence time in the Amazon Basin, and they concluded that a 10 to 20 percent reduction in precipitation would be sufficient to cause considerable alterations to the ecosystem. The isotopic composition of rainwater varies with the season of the year, but time-comparable variation was not observed in drainage water (*34*). This result suggests a mixing of waters and high water storage in the soil of undisturbed forest.

The distribution of rainfall is also important, and, although there is adequate total annual rainfall throughout the basin, there is in many regions, for example, Manaus, a marked dry period. If a relatively small reduction in annual rainfall resulted in an extension of the dry period, this could have serious consequences. Fearnside (*35*) has noted that in Manaus in 1979 there was a period of 73 days without rain. If such long dry periods were to become commonplace or extended, there would inevitably be a marked change in the natural vegetation.

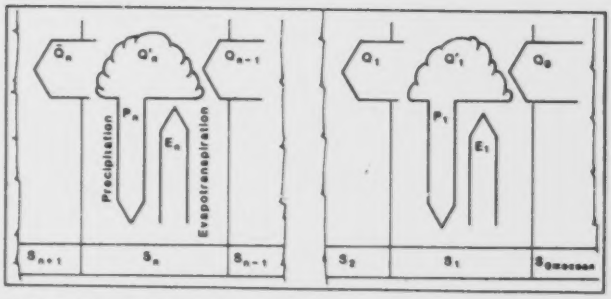

Fig. 2. Model to explain the distribution and recycling of rain (P) in the Amazon, assuming two sources of water vapor, the first from the ocean (Q) and the second from evapotranspiration (E). In any segment (S) about half the rainfall is derived from evapotranspiration recycling and half from water from the neighboring eastern segment ($I/4$).

Nutrient Balance, Gain and Loss

There is little quantitative information on nutrient recycling in the forests of the humid tropics, and the information that we have is fragmentary (*36*). The bulk of the stored nitrogen and phosphorus in the system is in the soil, roots, and litter of the forests, whereas the greater proportion of the cations, for example, Ca^{2+}, K^+, Na^+, Mg^{2+}, plus sulfur are in the standing biomass. In the mature forest system there is very little export or import of nutrients.

Klinge (*37*) carried out mineral analyses and constructed a balance sheet for soil and biomass of a high forest ecosystem near Manaus (Table 1). Only 20 percent of the total nitrogen and 27 percent of the total phosphorus are in the aerial parts, and by far the greatest proportion of both elements, of the order of 70 percent, is in the soil. In contrast, 66 to 80 percent of K^+, Na^+, Ca^{2+}, and Mg^{2+} are in the aerial parts. "Zero" Ca^{2+} was recorded in this soil of *p*H 3.5, as apparently long recycling has led to almost complete accumulation of this element in the biomass. Although there is no sign of nitrogen deficiency in the equilibrium forest, the large amount of nitrogen (12,201 kg ha^{-1}) is perhaps surprising. Of that, 2428 kg ha^{-1} was present in the aerial parts, representing a theoretical concentration of 0.59 percent nitrogen (dry weight). The amount of phosphorus in the aerial parts was very low (58.9 kg ha^{-1}), representing only 0.0145 percent.

Recycling in climax tropical forest is due to annual litterfall and the leaching of nutrients from leaves due to rain. There are some data (*38–40*) on litter

Table 1. Total amounts and distribution of major nutrient elements in a tropical high forest ecosystem (ferralsol, *p*H 3.5) near Manaus (*37*).

Component	Total in soil		Total in ecosystem	Portion of total in					
				Living biomass			Dead biomass (%)	Mineral soil	
	0 to 30 cm	30 to 100 cm		Aerial parts		Roots (%)		0 to 30 cm (%)	30 to 100 cm (%)
				%	kg ha^{-1}				
Nitrogen	4,263 kg ha^{-1}	4,661 kg ha^{-1}	12,201 kg ha^{-1}	19.9	2,427.8	4.6	2.4	34.9	38.2
Phosphorous	71 kg ha^{-1}	76 kg ha^{-1}	216 kg ha^{-1}	27.3	58.9	3.2	1.4	32.9	35.2
K^+	58 kg ha^{-1}	0 kg ha^{-1}	562 kg ha^{-1}	77.2	433.8	11.0	1.4	10.3	0.0
Na^+	35 kg ha^{-1}	15 kg ha^{-1}	291 kg ha^{-1}	66.3	192.9	15.5	1.0	12.0	5.2
Ca^{2+}	0 kg ha^{-1}	0 kg ha^{-1}	528 kg ha^{-1}	80.3	424.0	15.7	4.0	0.0	0.0
Mg^{2+}	17 kg ha^{-1}	6 kg ha^{-1}	298 kg ha^{-1}	67.8	202.0	18.5	6.0	5.7	2.0
Plant biomass			504 ton ha^{-1}	55.1		9.1	4.2		
Humus	113 ton ha^{-1}	120 ton ha^{-1}	233 ton ha^{-1}					15.3	16.3
Mineral soil (without humus)	3,349 ton ha^{-1}	9,373 ton ha^{-1}	12,722 ton ha^{-1}					26.3	73.7
Water	1,569 ton ha^{-1}	3,252 ton ha^{-1}	5,320 ton ha^{-1}	5.2		3.5	0.6	29.5	61.1

Table 2. Nutrient recycling in undisturbed South American primary forest.

Place	Litter (dry matter) (ton ha^{-1} year^{-1})	Nutrient recycling* via litter (kg ha^{-1} year^{-1})					Reference
		N	P	K$^+$	Ca^{2+}	Mg^{2+}	
Manaus, Brazil	7.3	106	2	13	18	13	(*38*)
Carare, Colombia	12.0	141	4	17	90	20	(*39*)
Mérida, Venezuela	4.6	57	3	20	31	12	(*40*)

*No data available for nutrient losses from tree foliage by rainfall leaching.

recycling (Table 2), and the amounts recycled annually are relatively small as compared with the total amounts likely to be in the standing biomass (Table 1). The amount of nitrogen recycled may be over 100 kg ha^{-1} year^{-1}, but the amount of phosphorus is as low as 2 to 4 kg ha^{-1} year^{-1}. Nutrient inputs to the undisturbed system come from the atmosphere as aerosols and precipitation and could be significant in areas being cleared by burning. Using proton-induced x-ray fluorescence analysis, Artaxo Netto *et al.* (*41*, *42*) found that the total concentration of the natural Amazon aerosol was under 10 μg m^{-3}, one of the lowest natural backgrounds recorded anywhere. Carbon, nitrogen, and oxygen comprise the major portion of the substrate particles, and amount to 80 percent of the total mass of natural aerosols and 99 percent of aerosols from brushfire areas. Table 3 shows the results of typical analyses, and it is apparent that burning forest does add appreciably to the aerosol nutrient content. However, if one takes into account the area burned at any one time in relation to the total area, the amount of nutrients recycled by this means must be comparatively small.

There seems to be agreement between the results of this and other work (*43*) that large-particulate matter of natural aerosols, such as aluminum, silicon, calcium, and iron, come from the soil, whereas fine particulates, such as sulfur and potassium, come from vegetation.

Input and output data for nitrogen have been calculated for a model basin (*44*) 60 km north of Manaus. For May and June 1980, the total mineral nitrogen inputs were 0.022 and 0.020 kg ha^{-1}, respectively, and the outputs were 0.017 and 0.009 kg ha^{-1}, respectively. Extrapolated to an annual basis, these figures are very low. Ninety percent of the nitrogen in the Amazon River is in organic form (*45*), and much greater total nitrogen values were calculated (*44*) from data for regional analyses of rain and river waters. These calculations indicated that 4 to 6 kg ha^{-1} year^{-1} are lost via the Amazon River and that a similar amount enters in rainfall. These values are similar to the early data of Sioli (*46*) for the input and output of nitrogen, phosphorus, and iron for the Rio Negro Basin. He found inputs and outputs not greatly different, with nitrogen and phosphorus inputs from rain slightly exceeding outputs and both very small in relation to the total.

There is very active biological nitrogen fixation in many Amazon ecosystems, and this has been estimated (*44*) to amount to a basinwide average of 20 kg of nitrogen fixed per hectare per year, although this seems rather a low figure. As input from precipitation and output to rivers are approximately the same, about 4 to 6 kg ha^{-1} year^{-1}, Salati *et al.* concluded (*44*) that losses of nitrogen by denitrification and volatilization would also be about 20 kg ha^{-1} year^{-1}. The overall nitrogen balance for the whole basin was estimated to amount to an input of 36×10^8 kg year^{-1} from precipitation plus an input of 120×10^8 kg year^{-1} from biological nitrogen fixation and a loss of 120×10^8 kg year^{-1} from denitrification and volatilization. Jordan *et al.* (*47*) found in the Venezuelan Amazon a total of 5583 kg of nitrogen per hectare in the biomass plus soil (60 percent in soil); the major inputs were from NH_4^+–N in precipitation (11.3 kg ha^{-1} year^{-1}) and from nitrogen fixation (16.2 kg ha^{-1} year^{-1}), with NO_3^-–N (5.7 kg ha^{-1} year^{-1}) lost by leaching plus nitrogen (2.9 kg ha^{-1} year^{-1}) lost through denitrification. There is a positive nitrogen balance of 18.9 kg ha^{-1} year^{-1}.

"Average" Amazon rainwater (*19*) has the following composition (in micromoles per liter): Na^+, 12.4; K^+, 1.0; Mg^{2+}, 1.2; Ca^{2+}, 1.1; Cl^-, 13.7; SO_4^{2-}, 5.1; NO_3^-, 2.1; NH_4^+, 0.5; and silicon, 0.0. Assuming an annual rainfall of 2000 mm, one can calculate that the average inputs of nutrient ions (in kilograms per hectare per year) are as follows: Na^+, 5.7; K^+, 0.78; Mg^{2+}, 0.58; Ca^{2+}, 0.88; Cl^-, 9.7; and SO_4^{2-}, 9.8. Such inputs are not large, but, as Venezuelan workers have shown (*47*) the forest has a whole series of mechanisms for the entrapment and conservation of nitrogen and nutrient ions from precipitation. These include mycorrhizae, rapid turnover of small roots, epiphylls which adsorb cations, sclerophyllous leaves and thick bark which prevent leaching, and slow release of nutrients from the surface layer of organic matter.

Thus, the effect of deforestation is likely to alter the nutrient balance through loss rather than through recycling. This loss will initially consist of the nutrients in the standing biomass (Table 1), but later there will be leaching losses from the disturbed soil. Forest is normally cleared by burning, which results in major loss of sulfur and nitrogen. Nevertheless, the total amounts of nitrogen added through the ash (1.4 to 1.7 percent) are high, as high as 127 kg ha^{-1} for

Table 3. Concentrations (in nanograms per cubic meter of air) of elements in Amazon aerosols (*42*).

Element	Concentrations in natural forest aerosol 60 km north of Manaus	Concentrations in typical aerosols from forest burning area, valley of Rio Madeira		
Al	43.59	6,264	0	3,678
Si	74.41	31,812	11,900	43,819
P	13.30	20,172	24,667	6,476
S	374.10	18,254	21,890	11,268
Cl	72.99	9,170	11,906	8,799
K	189.90	42,378	54,444	15,969
Ca	24.81	37,345	13,193	4,293
Ti	7.04	1,234	347	2,053
V	9.36	2,066	209	48
Cr	3.72	143	0	492
Mn	0.82	2,405	1,074	101
Fe	37.96	2,816	633	2,725
Ni	1.95	0	290	0
Cu	0.23	434	115	20
Zn	9.31	318	489	94
Br	1.66	727	0	147
Pb	5.01	1,482	237	48

a 25-year secondary forest burned at Yurimaguas, Peru (*48*), and 96 kg ha^{-1} for tropical forest similar to the Amazon at Turrialba, Costa Rica (*49*). Only 20 to 25 percent of the total nitrogen is lost through burning, whereas most of the K^+, Ca^{2+}, and Mg^{2+} is retained in the ashes (*48–50*). Nitrogen can be rapidly lost from the ashes with rain, as much as 15 percent with the first rainfall (*51*). Cations are similarly affected by rain and are leached from the surface soil (20 cm) (*52*). Salas and Folster (*50*) found that for a rather thin forest in Colombia losses on felling and burning were 30 to 80 kg of Mg^{2+} per hectare, 100 to 240 kg of Ca^{2+} per hectare, 60 to 140 kg of K^+ per hectare, and as much as 1300 to 1400 kg of nitrogen per hectare, including soil losses. Calculations suggested that rainfall inputs would make good the losses of cations in 10 to 20 years, on the assumption that forest regeneration were to occur, but that nitrogen fixation might restore the lost nitrogen in less time.

Traditionally much of the tropical forest areas have been farmed by shifting cultivation, under which land is cleared by burning and then a crop is grown for 2 or 3 years until yields decline and the cultivator moves on. With most of the nutrients accumulated over many years present in the ash, it is not surprising that the first crop after burning and clearing is good. The second crop, without the addition of fertilizer, is much poorer, and the third crop is either very poor or a total failure. The decline of fertility of cleared Amazon forest soil under poor management is typified by the degraded pasture area of Paragominas, situated in Pará State south of Belém. This area was extensively cleared for pasture, primarily *Panicum maximum*, and typically did not receive any fertilizer or legumes. There are now approximately 500,000 ha that are substantially degraded (*53*), and severe erosion is extensive, with part of this erosion due to overgrazing.

Typical Amazon forest soils have low *p*H, very high concentrations of exchangeable Al^{3+} and organic matter, and low concentrations of exchangeable cations and available phosphorus (Tables 4 and 5). When forest is cleared by burning, a large proportion of the nutrients are retained with the ash. At Paragominas, the effects are visible (Table 5) in the pasture a year afterward: *p*H is increased, exchangeable cations and phosphorus are increased, exchangeable Al^{3+} and aluminum saturation are greatly reduced, and there is a relatively small decline in organic matter. At the end of 7 years when degradation has occurred, there has been a reduction in (Ca^{2+} + Mg^{2+}) and a drastic decline in available phosphorus, a slight decline in nitrogen, *p*H remains 5.7 to 6.0, while organic matter has stabilized. It seems a general rule (*54*) that the organic matter of tropical forest soils declines about 25 percent on conversion from forest to cultivation, mostly in the first year, and thereafter the level appears to stabilize, rather contrary to accepted opinion. Although the general nutrient levels at Paragominas are not high, clearly lack of phosphorus has been the major limiting factor, and it has been shown (*53*) that addition of phosphorus greatly assists regeneration.

This analytical case history of a pasture soil is probably typical also of shifting cultivation sites in the Amazon, but results from Yurimaguas show that with modest use of fertilizer the case history can be different (*55*). Here, after 20 crops of upland rice, maize, and soybeans over a period of 8 years and with regular application of fertilizer, the soil showed the following composition: 1.55 percent organic matter, 4.98 meq of Ca^{2+}, 0.35

Table 4. Composition of soils of typical central Amazon high forest: Rio Madeira (*49*) and near Manaus (*82*). Data were averaged for a depth of 0 to 20 cm.

Location	Organic matter (%)	*p*H		Exchangeable cations (meq per 100 g)					Cation-exchange capacity
		H_2O	KCl	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	
Rio Madeira (*49*)									
100 km south of Porto Velho "Latossolo vermelho-amarelo" (red-yellow latosol)	3.16	4.7	3.6	0.17	0.10	0.10	0.02	1.3	2.80
Near Humaita "Laterita hidromorfica" (ground-water laterite)	3.00	4.3	3.8	0.04	0.06	0.10	0.01	2.5	4.32
100 km north of Humaita "Podzolico vermelho-amarelo plintico" (plinthic red-yellow podzol)	4.80	3.7	3.4	0.04	0.15	0.19	0.02	5.0	4.74
Experimental basin 60 km north of Manaus (*82*) "Latossolo amarelo, álicos argilosos" (clayey allic red-yellow latosol)	4.1	4.3	3.7	0.24	0.06	0.03	0.02		8.75

Table 5. Changes with time in the composition of an Amazon forest soil converted to *Panicum maximum* pasture; region of Paragominas, Pará State (*83*).

Sample	Organic matter (%)	Nitrogen (%)	*p*H (H_2O)	Ca^{2+} + Mg^{2+} (meq per 100 g)	Al^{3+} (meq per 100 g)	K^+ (ppm)	Phosphorus (ppm)	Aluminum saturation (%)
Forest soil before clearance by burning	2.79	0.16	4.4	1.47	1.8	23	1	53
After 1 year of pasture	2.04	0.09	6.5	7.53	0.0	31	10	0
After 3 years of pasture	3.09	0.18	6.9	7.80	0.0	78	11	0
After 4 years of pasture	2.20	0.11	5.4	3.02	0.2	62	2	6
After 5 years of pasture	1.90	0.10	5.7	2.81	0.2	66	3	6
After 6 years of pasture	1.90	0.09	6.0	3.84	0.0	74	7	0
After 7 years of pasture	1.77	0.08	5.7	2.61	0.0	47	1	0

meq of Mg^{2+}, and 0.11 meq of K^+ (all per 100 g of soil), with an aluminum saturation of only 1 percent and 39 ppm of available phosphorus. Moreover, a more favorable environment for deeper root development has been gradually created. Although the technology used at Yurimaguas is probably not, as we discuss later, the answer for the whole of the Amazon, it does show that soil degradation and loss of nutrient ions are not an inevitable part of forest clearance and cropping.

Probably of more importance than loss of nutrients is soil erosion, which has been, to a greater or lesser extent, the almost inevitable consequence of deforestation and conversion to cropping in other tropical areas (*26*, *56*). There are those who believe that erosion from the central Amazon Basin is not likely to be serious because the terrain is generally flat (there is a drop of only 60 m for the 3000-km Brazilian section of the main river, or a slope of 2 cm km^{-1}). In fact, the topography of the basin shows a series of small hills, some with quite steep slopes. A false impression of the terrain can be obtained from the use of large-scale topographic maps (*35*).

Total sediment and nutrient losses at the mouth of the Amazon are the summation of losses from three distinct types of rivers. The "blackwater" rivers originate from the white, sandy, poor, acid soils of the central Amazon, which characteristically have a surface mat of partly decomposed organic matter. The Rio Negro is typical of such rivers, which are extremely poor in nutrients but carry much suspended humic matter, from which they derive the color and name. The "whitewater" rivers, of which the Rio Solimões and the main channel are characteristic, carry high sediment loads derived from Andean erosion. The "clearwater" rivers are similar rivers from old eroded areas at the north and south edges of the basin. The little sediment that they originally contain completely settles out in "lakes" near the junction with the receiving river. An important feature of Amazonia is the *varzea*, that is, alluvial land that is subject to annual flooding at peak river flows and is capable of supporting the most productive agriculture in the basin. During flooding the new silt brought in by the river must more than make up for nutrient losses caused by leaching, but undoubtedly the nutrient relations are complex, and we have little information. It has been calculated (*57*) that the *varzea* floodplain covers an area as large as 100,000 km^2 along the main channel, which becomes a lake at peak discharge. Parts of the *varzea* are flooded for as long as 6 months at a time.

The analyses of various investigators (*3*, *19*, *45*, *58–61*) have provided substantial information concerning the total water discharge and the solid and dissolved materials, including carbon and important nutrient ions, transported by the Amazon. Gibbs's data (*59*, *60*) provide a useful basis for discussing both erosion and water chemistry, partly because the results are based on wet- and dry-season sampling, and particularly because the data were obtained well before the recent and current large-scale deforestation.

The rates of erosion and the amounts of solid and dissolved matter transported are shown in Table 6. Gibbs concluded (*59*) that the greatest influence on erosion and the total matter transported was relief. Thus 84 percent of the total load comes from the Andes, which amounts to only 12 percent of the catchment area. The total annual erosion was calculated as 116 ton km^{-2} $year^{-1}$, equivalent theoretically to a little less than 0.05 mm $year^{-1}$. Clearly, as the data are skewed by the Andean contribution, overall erosion in the central basin was quite low at that time. The proportion of dissolved matter was about one-third of the total load for the whitewater rivers, increasing to 50 to 85 percent for the blackwater rivers. The total of solid and dissolved matter (734×10^6 ton $year^{-1}$) is smaller than the total sediment flux (900×10^6 ton $year^{-1}$) later measured at Obidos by Meade *et al.* (*61*). This may represent a genuine increase between sampling years but possibly reflects different sampling procedures. The latter data are not based on seasonal cycle sampling, and Sioli (*58*) noted that there was a fourfold variation in the suspended load between dry and rainy seasons.

Table 6. Average erosion rate and transport of solid and dissolved matter in the Amazon system (*59*).

River basin	Erosion rate (ton km^{-2} $year^{-1}$)	Solid plus dissolved matter (10^6 tons per catchment area)	Dissolved matter (% of total)
Mountainous			
Ucayali	459.1	186.1	33
Marañon	344.4	140.2	27
Intermediate			
Napo	213.1	26.0	14
Içá	78.8	11.7	22
Japurá	131.1	66.3	48
Madeira	199.7	215.4	27
Tropical			
Javari	79.8	8.5	14
Jutaí	45.8	3.4	11
Juruá	82.6	17.9	40
Tefé*	14.6	0.4	85
Coarí*	15.2	0.8	87
Negro*	20.0	15.1	50
Purus	73.5	27.3	41
Tapajós†	5.0	2.5	76
Xingú†	4.0	2.0	75
Araguari	17.2	0.8	56
Amazon (mouth)	116.0	730.3	32

*Blackwater rivers. †Clearwater rivers that have also sedimented out before the point of sampling.

It can be postulated that the elements that show varying concentrations are the result of a constant supply diluted by a varying amount of water at different times of the year. Such a situation might arise where ions derive from source rock and where a major rapid increase in precipitation is not matched by the solubilization of ions. Stallard's calculations (*62*) support this idea in part and suggest that 40 to 60 percent of Ca^{2+}, Mg^{2+}, Na^+, and sulfur and as much as 90 percent of Cl^- are derived from Andean headwater sources, but that most of the K^+ and silicon transported by the river comes from weathered basin soils. Gibbs suggested (*60*) that both Cl^- and Na^+ were derived primarily from precipitation, on the basis that the Cl^-/Na^+ ratio of river waters approximates at maximum discharge the value for seawater, and that Cl^- has apparently few sources other than precipitation. Recent work does not support precipitation as a major source, and Stallard and Edmond (*19*) have calculated that the proportion of "cyclic salts," that is, atmosphere-derived salts ultimately returned to the oceans, makes only a minor contribution to the chemistry of the Amazon. They estimated that the proportion of cyclic salts in the dissolved load at Obidos (about 80 percent of Amazon waters) was as little as 17.6 percent Cl^-, 0.9 percent Na^+, 1.3 percent Mg^{2+}, 3.6 percent sulfur, 0.4 percent K^+, and 0.1 percent Ca^{2+}.

Kempe recently reviewed (*31*) a number of cycles of river analyses and found that the concentration of dissolved solids peaks in March when Andean-derived water reaches Obidos; when waters rise farther, the concentrations decline substantially, increasing slightly again as the water level drops. Concentrations vary by a factor of 2.5 over the year, thus confirming the postulation of Gibbs (*60*). The maximum SiO_2 concentration uniquely occurs well after the total dissolved solids have reached peak concentration and after the main rise in water. This finding tends to support Stallard's (*62*) suggestion that silicon comes from the lowland area, as these waters reach Obidos after the upland river waters. On the Rio Negro, phosphorus, total PO_4^{3-}, total iron, and dissolved iron tend to peak as the waters recede; this finding suggests that these components are a result of leaching, but the total amounts are small (*46*).

We should stress that brief interpretations such as those discussed in this section are gross oversimplifications, as we are dealing with very complex systems. As Richey has recently reported (*57*), the river, its sediments, and the *varzea* may store carbon, nitrogen, phosphorus, sulfur, and probably other elements for substantial periods of time. What does seem clear, however, is that at present the major output of nutrients at the mouth of the Amazon is primarily due to Andean erosion. There appears to be comparatively little loss from the stabilized soils of the central basin itself.

Heat Balance and Climatic Change

Sunlight intensity in the central Amazon is high, reaching at the limit of the earth's atmosphere a maximum of 885 cal cm^{-2} day^{-1} in January and falling to a minimum of 767 cal cm^{-2} day^{-1} in June. The incident energy reaching the ground is much less but has a relatively high value, 559 cal cm^{-2} day^{-1}, in April (*63*, *64*). The mean daily radiation at Manaus for the period 1977 to 1979 was 373 cal cm^{-2} day^{-1} (*64*). There is a high frequency of cloudiness, and the number of hours of sunlight is only about 50 percent of the theoretical maximum.

Mean monthly temperature shows little variation. At Belém, the mean maximum temperature of 26.9°C occurs in November and the mean minimum temperature of 24.5°C occurs in March. The corresponding mean montly maxima and minima for Manaus are 27.9°C (September) and 25.8°C (April), and for Iquitos are 32°C (November) and 30°C (July).

Table 7. Composition and mass transport rate of the dissolved salts of the Amazon River (*60*).

Component	Dissolved salt concentration (mg $liter^{-1}$)			Mass transport rate (10^6 ton $year^{-1}$)
	Minimum	Maximum	Average	
HCO_3^-	15.0	33.5	22.5	124
SO_4^{2-}	1.7	4.7	3.0	17
Cl^-	3.2	5.0	3.9	22
NO_3^-	0.1	0.3	0.2	1.1
PO_4^{3-}	0.01	0.25	0.04	0.22
Ca^{2+}	3.9	10.4	6.5	36
Na^+	1.94	5.25	3.1	17
Mg^{2+}	0.81	1.40	1.0	5.5
K^+	0.4	1.35	1.0	5.5
SiO_2	9.1	12.42	11.2	62
Fe^{2+}	0.002	0.1	0.03	0.16
Al^{3+}	0.02	0.06	0.04	0.22
Total	39.4	73.1	52.9	292

North and south of the basin, toward the high plateau of Guyana and the plateau of central Brazil, there is greater continentality, with well-defined dry periods and lower temperatures. In the Andean region, low temperatures are common and at the higher levels the most significant precipitation is in the form of snow. Important phenomena that can cause major variations in temperature, sometimes with ecological consequences, are the "friagem" or cold spells that occur when air masses originating in the South Polar region hit the central and western parts of the basin, when temperatures can fall to about 14°C.

Removal of forest and substitution by other vegetation must inevitably affect the atmospheric heat balance, because with this change the albedo (the ratio of reflected to solar energy) increases. Forests have the lowest albedo, deserts the highest, with savannah intermediate; forest removal increases the albedo from about 0.13 to 0.16 (*65*). Therefore, the amount of solar energy absorbed by the ground cover is reduced and more energy is reflected and lost to space, whereas the energy available for heating the overlying air and for convection is also reduced. Albedo values have not been determined specifically for the Amazon Basin, and those used by different workers have varied somewhat (*66*).

The energy and hydrological cycles are closed linked. The energy absorbed by both the forest and the bare ground is returned to the atmosphere as sensible and latent heat. Sensible heat is the result of the cooling of ground cover by the passage of air, and the heat transferred from the surface warms the earth's atmosphere directly. Latent heat is derived from the energy lost by leaf, soil, and other surfaces when water is vaporized through evapotranspiration. This heat is then subsequently released as sensible heat during the formation of clouds. The ratio of sensible heat (H) to latent heat (E) (the Bowen ratio, $B = H/E$) can be substantially modified by forest removal, although such heat-flux changes are changes not in the net energy absorbed but rather in the exchange of energy between the surface and the atmosphere. What weight should be given to albedo effects as compared with the change to be expected in the Bowen ratio? Fränzle claimed (*13*) that quite a large change in albedo does not yield an essential change in the production of sensible and latent heat. However, the Bowen ratio can be substantially altered by deforestation, and, as sensible heat remains essentially the same in the short term, we are primarily examining potential changes in evapotranspiration (E).

Molion and Bentancurt (*67*) have demonstrated that evaporation differences among cover types, assuming water is not limiting, can be quantitatively explained purely in terms of energy considerations, and that forests evaporate more water than any other type of cover, as much as twice that from bare soil. There are also good practical reasons why this is so: water recharge of the forest soil is good and the tree roots exploit a large volume of soil, as they can tap water at greater depths than most annual crops or replacement vegetation. Nevertheless, evaporation from bare or partially covered soil can be high, even though theoretically the increase in albedo from deforestation should result in decreased absorption of solar energy. On a local scale, without the shade of the forest canopy, greatly increased solar radiation reaches the soil surface. In virgin forest in Guatemala only 4 percent of the solar radiation reached the soil surface, and the solar energy reaching cleared soil was 25 times as much (*68*). In Ghana forest clearance led to an increase in the maximum soil temperatures at a depth of 7.5 cm from 27° to 38°C (*69*). Although the rate of evaporation from bare soil after rain may be very rapid, as is self-evident to anyone familiar with the tropics, this is a short-term phenomenon that affects only the surface soil; without further rain vapor the flux will rapidly decline as the top soil dries out, whereas the forest will continue evapotranspiring water from deeper soil. Although the grass cover may show a high rate of evapotranspiration the runoff is also high.

There is no knowledge of "scaling effects" on evapotranspiration in the Amazon, or anywhere else (*21*). Within the small clearings of shifting cultivation there is likely to be little detectable effect as the moist air from the surrounding forest will swamp any drier air. Since the recycling of water in the Amazon Basin will have been reduced by a small amount, the cumulative effect of a large number of clearings could be large. Because the rate of evapotranspiration is determined by the saturation deficit and temperatures, the additive effect of dry air from large cleared areas on the remaining forest could be considerable. It has been observed that after long periods of drought the outer trees of the forest next to cleared land are the first to show signs of stress. One, possibly extreme, suggestion (*13*) is that extensive destruction of the forest could lead to a Bowen ratio exceeding 2.0. This suggestion implies that previous source areas of latent heat would become foci for the generation of large amounts of sensible heat.

Salati *et al.* (*21*) have postulated that widespread deforestation of areas such as the Amazon, where the rainfall regime is especially associated with recycling, sets in motion a chain of events. There is an immediate increased surface runoff, such water is rapidly lost to the rivers and ocean, without the possibility of its recharging the soil system and of its recycling through transpiration and precipitation. Evapotranspiration will continue at a high although reduced rate, returning moisture to the atmosphere, but it is drawing from a decreasing soil water store. Therefore, ultimately there will be a reduction in the amount of water recycled to the atmosphere and hence diminished local cloud cover, and diminished precipitation, with the net effects that there will be less total water in the system and an increase in solar radiation. The close connection between forest and low cumulus has been shown by satellite photographs (*70*). Amazonian rivers stand out as cloud-free areas, and part of this contrast is due to the reduced latent and sensible heat distribution over the rivers as compared with that over land. Even on commercial airline flights, it is possible to see that the cumulus cloud sometimes arises from the very top of the forest and that, where the forest thins out as a result of development, there is less cloud.

A number of attempts have been made to model the potential climatic effects of Amazon deforestation. Potter *et al.* (*71*, *72*) used a two-dimensional zonal atmospheric model, assuming a rather extreme albedo change from 0.07 to 0.25 (*71*) and assuming an increased runoff rate and decreased evaporation rates. Their results anticipated a decrease in precipitation of 230 mm year^{-1} between 5°N and 5°S. Lettau *et al.* (*14*) used essentially a surface energy balance model which took into account profiles of precipitable water in the atmosphere, exchangeable soil moisture, and annual mean profiles of surface and air temperature. They assumed that evapotranspiration would increase as a consequence of deforestation, and the model required a Bowen ratio that was dependent on the sum of sensible and latent heat fluxes remaining constant as evaporation changed; that is, changes in absorbed solar radiation had to be balanced by the net emission of thermal infrared radiation. The results suggested a warming of less than 1.5°C and, somewhat surprisingly, an increase in precipitation of 75 mm year^{-1}. Henderson-Sellers (*73*) used the three-dimensional general circulation model of the Goddard Institute for Space Studies, which included seasonal albedo changes and the moisture-holding capacity of soil. Her results suggested a decrease in rainfall of 600 mm year^{-1} and a small temperature increase.

These results are clearly contradictory, and this in part derives from differences in the nature of the models and in the essential assumptions. The global procedure of Potter *et al.* (*71*, *72*) has an advantage in that it does not have artificial boundaries, but it has the disadvantage of relatively poor resolution. The models of Lettau *et al.* (*14*) and Henderson-Sellers (*73*) were clearly Amazon-focused, but they differ in that the latter is atmospheric-based whereas the former depends on surface energy balance. The prediction (*14*) of a precipitation increase as a result of deforestation appears scarcely credible and seems to arise from the overreliance of the model on evapotranspiration and in particular on the assumption that evapotranspiration increases with deforestation.

Although primarily concerned with albedo change in semiarid regions of Africa, the model of Charney *et al.* (*74*) supports our general thesis. Charney *et al.* suggested regional reduced precipitation and perhaps high temperatures, resulting from an increase in albedo together with a major decrease in evapotranspiration. The original model of Potter *et al.* probably overestimates the albedo effect, but their assumption of increased runoff rate and decreased evaporation rate seems realistic, and the results are in the correct direction. We are not experts in climatic modeling, but from the considerations outlined above in particular, recycling of precipitation, the real loss of water from the soil system, and the scale effect of clearing unprecedentedly large areas of forest, we believe that the Henderson-Sellers (*73*) estimate of a decrease in Amazon rainfall of about 600 mm year^{-1} is, to date, the most reasonable interpretation of the situation.

Potential Consequences of Disequilibrium

The latest official figures (*75*) for Brazilian Amazon deforestation suggest that at the present time at least 2.3 million hectares of forest are being destroyed each year, and for reasons discussed elsewhere (*5*, *20*) the area might well be greater. Changes are inevitable, but to what extent we still cannot predict. The tropical forests of Amazon, Africa, and Southeast Asia (especially Indonesia and Malaysia) have hitherto occupied 50 percent of the land area of the 20° equatorial belt and make the largest contribution to global latent heat flux. This flux is transferred, in the form of clouds, by the atmospheric general circulation to balance the negative radiation flux of the polar regions. For this reason Newell (*76*) suggested that removal of tropical forests in the Amazon and Indonesia might have major effects on the general atmospheric circulation and therefore have consequences far beyond the tropics. So far this idea remains just a possibility, as there is no really good indication from modeling studies that major direct intercontinental effects will result from Amazon deforestation. Potter *et al.* (*71*) suggested that there might be a small decrease in precipitation of 1.5 to 2.0 percent in latitudes above 45°N, whereas Henderson-Sellers (*73*) thought the only global perturbation would be the result of a small addition of carbon dioxide. Recently Dickinson (*66*) concluded that global climate changes due to even complete tropical deforestation are not likely to be larger than natural climate fluctuations but that regional climate changes are likely to be considerably larger.

Although the trend of opinion is reassuring it should be emphasized that we do not really know very much about this question. The number of modeling studies is quite small and they all have limitations (*77*). Much more study is needed before it will be possible to be reasonably sure of the consequences of tropical deforestation on global climate. At present, we feel fairly certain that Amazon deforestation will cause major changes in the basin itself, especially if the prediction (*73*) of an average decrease in pre-

cipitation of 600 mm year^{-1} is correct. In the region of Manaus the present dry period is already the maximum that the ecosystem can withstand, and any lengthening of the dry period, or possibly reduced rain at other periods, would induce irreversible changes. At present, forest fires do not start naturally in the Amazon because of the humidity. A reduction in rainfall can be expected to change this situation: it would not be possible to control such fires by human intervention. Rather perversely, despite predicted long-term reduced precipitation, there are already signs that we can expect deforestation in the upper Amazon to lead to an increased frequency and degree of flooding of the *varzea* in the lower Amazon. This will affect the agricultural production of some of the basin's most fertile soils.

The effects of reduced precipitation in the basin would probably be felt in Brazil beyond the immediate area. The climate of South America is determined primarily by the general circulation of the atmosphere and the oceans. Nevertheless, there is a certain amount of continentality with local control factors in the Amazon. A reduction in the precipitable water in the basin could mean that there would be less water available for export to the Chaco Paraguayo and central Brazil. A drier regime in the Amazon Basin and reduced rainfall in central Brazil could strengthen the tendency to continentality, which might affect climatic patterns and agriculture in south-central Brazil.

For example, the *cerrado* region of the altiplano already suffers from too little precipitation, and the current type of agriculture of São Paulo State is precariously balanced in terms of frost. During the winter of 1981 in the interior of São Paulo, near Piracicaba, all bananas were killed off by frost, sugarcane leaf tips were frost-burned, and a substantial part of the orange crop of the Limeira region was lost. Any shift toward continentality that either extended the winter period or induced lower winter temperatures could completely change the agriculture of the region. This would mean the loss of the valuable export production of sugar, oranges, and coffee, grown on some of Brazil's best soils, and a major setback to the import-saving alcohol fuel program.

Deforestation of the Amazon is likely to affect major natural systems beyond our present comprehension. Therefore, it is highly advisable that very large areas of forest should be retained and that policies for development should be directed toward sustained utilization. Annual cropping systems are appropriate for the relatively good soils of Rondonia, Acre, and the Peruvian Amazon, but for most of the Brazilian Amazon rational development should aim to preserve as much of the forest canopy as possible. This means the development of managed forestry. *Pinus caribaea* grows well there as does the valuable jacaranda [*Dalbergia nigra* (78)], together with tree crops such as cocoa, palm, rubber, and coffee under shade. Agroforestry systems, with the integration of small-scale production of cassava, dryland rice, maize, and grain legumes, together with managed forestry, offer the possibility of supporting food needs while maintaining the water cycle and restricting erosion. Large-scale clearance for cattle pasture and annual crops grown in large exposed fields would, according to our present knowledge, be the worst type of Amazon development, leading to major water runoff, erosion, and soil degradation, and the greatest possibility of induced climatic change.

Disequilibrium will have major impact on Amazon animals, indigenous peoples, and the flora (79). There remains a wealth of still unresearched exotic plant and animal life in Amazon that is in danger of being lost, even with the extensive reservations that are being established (*80*). There are over 23,000 identified plant species but countless others waiting to be discovered (*81*). Most of the existing plant species have not been screened to determine whether they have properties that might be valuable for medicine or industry, and rapid major changes may cause their loss with no chance of recovery.

Much data on the Amazon natural system are lacking, and many data are unreliable. Base-line studies are urgently needed, so that potential changes can be better understood.

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AGAPAN

Who is destroying the Amazon rain Forest?

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We are witnessing today in Brazil and in much of Latin America the biggest holocaust in the history of Life. Never in the course of three and a half thousand million years, since the first stirrings of Life on this planet, has there been such a wholesale, accelerated, violent and irreversible demolition of all living systems as today. We have passed the point where we only desecrate this or that scenic landscape, this or that ecosystem. We are now in the process of demolishing whole biomes. Now we are getting ready to finish off the last large, more or less intact and contiguous jungle on Earth, the Hylaea, or tropical rain forest in Amazonia.

Nobody seems to know exactly how fast the forest is be ing demolished. No statistics are published and Landsat images are not easily accessible to and interpreted by those who really care, while the powerful have an interest in downplaying the extent of the devastation. In a recent interview on TV the Governor of the State o Amazonas, who is now pleading for free, largescale export of raw timber logs and animal hides, stated categorically that less than 2% of the forest had been cleared until now. On the other hand, serious scientists who know Amazonia very well, Harald Sioli, f.i., state that close to 100 000 km² of forest are felled every year. That would be about 2% a year and this has been going on for at least a decade.

Assuming exponential trends, Philip M.Fearnside at INPA (Intituto Nacional de Pesquisa da Amazônia) [1] shows that the states of Pará, Maranhão, Goiás, Rondônia and Mato Grosso would be cleared by the year 1990. Acre would be totally deforested before the year 2000, Roraima and Amazonas shortly after the year 2000. Only Amapá would survive into the 22nd century. Averaging out these trends the total of the forest would be gone well before the year 2000! We must not let this happen.

The systematic destruction is done in the name of "progress". The Brazilian Government, the military dictatorship which set itself up in 1964, set course for"development" at any cost. Their definition of development is the technocratic one - an economic model geared to fast industrialization, where the highest aim is megatechnological concentration and a cash crop agriculture, with vast monocultures, to feed industry and the export market.

Large scale devastation of the tropical rain forest and its surrounding transition type forests takes several forms. At one extreme we have gigantic projects. Multinational or Brazilian corporations or powerful individuals go to Amazonia to multiply capital. Among them are such giants as Anderson Clayton, Goodyear, Volkswagen, Nixdorf Computer, Nestlé, Liquigas, Borden, Kennecot Copper, and the American multibillionair David Ludwig, or even farmers cooperatives from the south of Brazil, such as Cotrijuí. But this is a very small fraction of the list. It runs into the hundreds. These outfits set up enormous projects - cattle ranches, paper mills, single species monocultures of exotic trees for pulp, immense rice plantations, sugar cane plantations for the alcohol program, timber mills, mining operations.

[1] Deforstation in the Brazilian Amazon: how fast is it occurring?
Philip M.Fearnside, INTERCIencia, Mar-Apr 1982, Vol 7, No 2

More often than not, these operations are financed with state subsidies - tax rebates. That's why they are extremely wasteful and can accept scandalously low rates of productivity. On the extensive cattle ranches the production of meat hardly reaches 50 kg per hectare per year and it rapidly declines after a couple of years as the soils are leached of the scarce nutrients remaining after deforestation. The grasses and legumes sowed for pasture give way to scrub unpalatable to cattle. The scrub is then kept down with heavy machinery, annual burning or herbicides. This contributes to still more destruction of the soil and still lower production. In northern Europe, on organic farms not using imported feed, meat production is closer to 600 kg/ha/y plus between 4000 and 6000 liter of milk per hectare. No milk is produced on the Amazonian cattle ranches. We must remind ouselves that the intact forest, obliterated to give way to pasture, can produce at least ten times as much food in the form of tropical fruit, game and fish. Every single adult Brazil nut tree left in peace can produce hundreds of kilos of precious food, every pupunha palm tree or many of the innumerable other species of palm trees occuring in the forest can produce dozens of kilos of food, feed and construction material. For the inhabitants of the forest there also is no limitation concerning firewood, a problem that is becoming extremely serious in other parts of the world.

Another devastating effect of those schemes, this one social, is that they employ an average of one worker per two thousand cattle, that is, one person on at least 3000 hectares! The same area of forest could easily feed and house several hundred people if left intact. The traditional life style of the Indian, the caboclo and the seringueiro (rubber tapper) is also much more pleasant, easier, independent and secure than the life style of the ranch worker. The irony of it all is that the little meat produced is meant for export. The Amazonian caboclo wisely says - where cattle move in, we move out, cattle mean hunger. The only beneficiaries are the corporations who don't even spend the money in the areas they devastate. But they keep saying that they are in the business of feeding starving humanity...

The social devastation of the other schemes, extensive monoculture of trees, open pit mining, gigantic dams, timber mills and logging on an industrial scale, commercial fishing for export, are just as bad. They are all geared to the enrichment of the powerful from outside the region. There is no concern for the needs of the local population, much less for their life style and culture. The local people are uprooted, marginalized, alienated and they go either to the slums or escape ever deeper into the jungle, as long as there is jungle. The Indians are already reaching the end of the line.

The Brazilian government is now selling off whole mountains, such as in the Carajá Project. Recently our minister of planning boasted of having received the first downpayment of a few hundred million dollars from Japan for ore to be mined in the Carajá mountains. What will future generations say?

It might be worth mentioning one particular megatechnological project almost completed which is now very much in the news - The Tucuruí dam in the State of Pará on the Tocantins River. 200 000 hectares will be flooded. Thousands of people and two Indian tribes have been driven off their land. 8 000 megawatts will be produced in the middle of the jungle where there was no demand for electricity. It will be used for the mining operations in Carajá and

to make aluminium for export. The true beneficiaries will be overseas. Now that the dam is almost completed it turns out that the forest that will be flooded has not been cleared. A company charged with the job, a military pension fund (! ?) that was supposed to make large sums in foreign exchange to help pay Brazil's foreign debt by exporting the valuable timber, received large foreign loans instead. The money disappeared. Thousands of workers who were brought from far away were left stranded, their salaries unpayed. The intention now is to spray the forest with agent orange and to set fire to it, timber and all. This is typical of all large projects in Amazonia. While in other parts of the world millions of people are in dire need of firewood, in Amazonia millions of tons of wood are senselessly burned or left to rot in the fields, the larger, charred trunks pointing to the sky.

Before the big spraying begins we already have a new agent orange scandal. The utility in charge of the dam sprayed this "defoliant" on its right of way under the transmission lines. Cattle and children died. Pregnant mothers aborted and died too.

At the other extreme we have large scale demolition of the forest by small settlers, but this is also due to outside forces. The State of Rondonia, the westernmost state of Brazilian Amazonia, about the size of Great Britain, is being systematically cleared by settlers at a rate that, if continued, will leave it without forest by the year 1988. The small settlers are more efficient destroyers of the forest than the big companies who usually abide by the law that requires them to leave half the forest intact. The settler cannot stop, he must go on clearing until nothing is left. Rondonia was chosen as an escape valve. Our colonization agency, INCRA (Instituto Nacional de Colonização e Reforma Agrária) circulates whole page ads showing aerial views of forest being cleared by settlers. The legend says - Brazil is making the largest agrarian reform in the world. But these settlement schemes are conceived precisely in order not to have to face agrarian reform in other regions. The settlers come from the North East where landlords have always prevented a healthy peasant culture from developping and from the South, where soybean monoculture, producing feed for the cows that produce the "butter mountain" in the Common Market, also drives thousands of people off their land. Farther north, in Central Brazil, the alcohol program is also displacing masses of people.

The migrants from the South are often the third wave of migration in a century. German and Italian imigrants came to the old colonies in Rio Grande do Sul and Santa Catarina in the last century. Their descendants moved to the Uruguay river Valley. In the nineteen fifties they moved to West Paraná, then on to south Mato Grosso. The frequency of migration waves is becoming shorter. Some families are now moving for the second time. They will probably not stay long in Rondonia.

Hundreds of migrants arrive in Rondonia every day in addition to those unhappy people, much more numerous, who can only escape to the slums of the big cities. Some of the migrants try to settle on their own. They simply move to jungle areas as they become accessible through the new penetration roads that are constantly being opened by the road authorities. If they are lucky, they eventually get title to the land they settle on. For this they have to prove that they have made "improvements" on it. INCRA accepts as improvement the clearing of forest. Hence every wild settler cuts down as much forest as he can, often much more than the area he can cultivate. Some bigger guys cut hundreds or thousands of hectares. Many of the settlers go from one clearing to another. As soon as they get title or sufficient proof of property they sell to big outfits and move on. We have met settlers who make a living out of such land speculation.

The more common case, though, not so much in Rondonia, but in other remote regions of Brazil, is that the wild settler is soon displaced by someone who comes with "legal" title to enormous tracts of land. The settler is then considered a squatter and driven off by the "jagunço" a hired gunman. No records are kept of the names and numbers of those who disappear.

Where the migrants settle legally they end up in the settlement schemes of INCRA. These schemes are another example of total disregard for the Amazonian landscape and its people. The division of the land is conceived on the drawing board. A checkerboard-like pattern is imposed on the land without the slightest concern whatever for topography, steep slopes, rock outcroppings, little rivers or brooks, much less ecosystems - a concept that doesn't exist in the heads of INCRA planners. The lots are 250 by 1000 or 500 by 2000 or even 4000 meters. Thus, the farmer actually gets a long strip of land. In some cases his strip cuts across the meanders of the same waterway several times. He will have to build several bridges. Another farmer may have no access whatever to water, or his land may cut across two steep slopes with two high plateaus and some lowland in between or vice versa. Inevitably he will cut down the forest on the slope. The soil will be eroded away after the first harvest, if any. Even the areas officially left as forest reserves are marked on the map as geometric shapes, somewhere in a corner of the project, without reference to landscape. Then there is absolutely no provision for the preservation of these areas. The INCRA people say it is the responsibility of IBDF (Instituto Brasileiro de Desenvolvimento Florestal - the forestry agency); IBDF says it has no means to take care of the reserves. In no time they are destroyed by wild settlers. It often seems as if the whole scheme were deliberately set up so as to guarantee maximum devastation.

The farmers are left to themselves. There is no agricultural extension service worth that name. Government extension agencies promote cash crops and the credit system is geared to monoculture. Most credit plans include a certain percentage centage of the money for pesticides and chemical fertilizer, regardless of need. Cash monoculture is controlled by specialized agencies such as CEPLAC for cocoa, IBC for coffee, SUDHEVEA for rubber tree plantations. Each agency insists on pure monoculture. Where farmers, out of their own wisdom, make mixed stands of coffee, cocoa, rubber and citrus trees, each agency threatens to cut credit unless the farmers turn to pure monoculture of the respective crop. But practice has shown that mixed stands make for healthier plants, require less or no pesticides and produce more on a more sustainable basis. An official experiment station in Rondonia will probably soon "prove" that mixed stands will not work. Though they have plots with mixed stands, they use herbicides and soluble nitrogen fertilizers from the start. Even on very young trees they have all kinds of pest problems. There is no pest problem on rubber trees in the forest.

Socially too, the settlement schemes are very disruptive. First, by helping to prevent the necessary reforms in the regions where the migrants come from, and second by destroying the social fabric in the settlement areas. Those areas were not empty, as is often claimed. Third, the new settlers will soon be in serious trouble too, when they have degraded all their soils and there is no more virgin forest to move into. We have seen settlers on soil so poor that even in the ashes of the clearing their harvests were not enough for survival.

The Indians are pitilessly liquidated, the survivors are driven ever deeper into the remaining jungle, until they meet the advance from the other end. MOreover the rain forest Indians are extremely vulnerable to some of our diseases, such as common cold, measles and VD. As soon as a tribe makes contact with the "civilised" invaders they face lethal epidemics. Often as many as 90 % of a group die within a few years. For the few survivors it is the end of their culture. It is sad to see the total demoralization of the so called "civilised Indian".

The disappearance of the rain forest Indian cultures is perhaps one of the greatest tragedies of our time. The rain forest Indian is a true ecologist. He knows the forest as no modern ecologist can possibly get to know it. He reveres it. Yet our criminal economic models are exterminating them before we can even learn from them, just as we are exterminating tens of thousands of species every year even before we can catalogue them.

Our indecent lifestyle seems to be trying to make sure that, when it collapses, there will be no alternative lifestyles left to take its place.

The new settlements also displace the caboclo and the seringeiro. The caboclo is the successor of the Indian, usually of mixed stock, white and Indian, sometimes Negro. He lives in the forest, surviving from shifting agriculture and as a hunter gatherer. His lifestyle is quite compatible with the survival of the forest, as long as his population doesn't increase too much. But we are still very far from that. He has no reverence for the forest and its animal life but he keeps much of Indian wisdom.

There is also the small logger. He too is compatible with the survival of the rain forest. He logs only on the flood plains from where he can take his logs out when the water is high, making rafts for transportation to small lumber-mills. Felling is selective with little harm to other trees. A very important point is soil fertility. On the flood plains we have the only really fertile soils in the rain forest. The flood plains are fertilized every year, just as was the case in the Nile valley before the Aswan dam. Trees grow fast on the flood plains. Old loggers often resume logging where they started in their youth. In 20 to 30 years enormous trunks grow back, the size of trunk that it would take two centuries to grow in Europe.

Where the big multinational logging companies or the large timber companies from the south of Brazil move in the situation is quite different. They do not limit their activities to the flood plains but operate mostly on the highlands, where soils are extremely poor and regeneration is therefore much more difficult. They also use heavy machinery, causing tremendous havoc, often destroying the whole ecosystem. They are required by law to "reforest". But reforestation consists only of commercial monocultures. This reforestation is often done by specialized companies. The law does not require reforestation to be made in the place where the forest was logged, it is often done somewhere else, even thousands of kilometers away. The reforestation companies often destroy natural ecosystems, other forests, for their plantations. This is so because it is easier to get large tracts of contiguous land in the remaining wilderness areas. The "reforested" area is also almost always much smaller than the area of forest destroyed by logging and there is no control and bribing is easy.

Local fishermen, who until recently provided 80% of Amazonias protein are also being driven off by progessional fishing boats. It is often said, even by those who want to save the forest, that the Amazon can feed the world with fish protein. That is another illusion. There is enough fish for a growing local population but not for large scale export business as it is developing today. The Amazonian rivers are incredibly rich in fish. There are more than one thousand different species. Many have not even been classified by zoologists. But there is very little primary production in most of the Amazonian rivers. Fish life is mostly dependent on the forest, especially the forest on the flood plains. Many species feed on fruit or forest residues only during the high water season when they leave the river bed and spread out into the plain. The rest of the year they live off their fat reserves. All destruction of flood plain forests and also of forests along the smaller waterways in the highlands contributes directly to diminution of water fauna. Even today there is overfishing. Some important species such as the pirarucu and the tambaqui are nearing extinction and the manatee is very close

to extinction. Commercial fishing is also extremely wasteful. It is now common practice for fishing boats to throw overboard whole loads of commercially less valuable fish when they hit upon a school of more valuable species. While fishing for local consumption is done locally, often by the consumers themselves, the commercial fishing fleets have autonomy over thousands of kilometers. In many areas the local population already complains that it is becoming difficult to catch the fish it needs.

Finally, there is the seringueiro, or rubber tapper. Like the Indian, he has no sense of land ownership but he has a sense of territory. Each seringueiro has his "estrada", or road. He may walk as much as 30 km a day collecting the latex. Today he is no more the slave laborer he was in the past. His transistor radio informs him of the rubber price in São Paulo or Chicago. He makes between five and sevenhundred dollars a month, as much as a metal worker in São Paulo, but he has no expenses. He derives most of his food from the forest and the river. He also has no transportation costs. Yet the colonization programs are displacing the seringueiro too. Another lifestyle compatible with the forest is being destroyed.

Brazil imports two thirds of its natural rubber consumption of approximately 90 000 tons a year. By helping the seringueiro and by increasing the density of the rubber trees in the forest, which has already been proved possible by some small private enterprises, Brazil could easily have enough natural rubber for export. The monocultures of rubber trees that are now being promoted by the government will probably not last long. The experiment carried out in the 1930s by Ford was a failure. In monoculture the rubber tree is subject to all kinds of pest attack.

The rubber tappers income comes not only from rubber. He also collects Brazil nuts. He would be the ideal forest guard, requiring no pay from the government, and although it is true that in the past he contributed to much slaughter of Indians today, in many areas, rubber tappers and Indians have learned to live together in harmony. During the last World War the central Government, which then called the seringueirc "o soldado da borracha" (the soldier of rubber) promised him title to the land on which he worked. This would have been very easy to implement. Each seringueiro needs no more than 200 - 500 ha. If the density of rubber trees in the forest were increased. Of course the promise was seldom fulfilled. We know of only one program where some seringueiros were given 250 ha. In general, when the seringueiros are displaced by the colonization projects, they get no more than 25 ha. They invariably sell the land and end up in the slums or as day laborers on some big project.

The federal government sees no difficulties in granting the rich title to tens of thousands or even hundreds of thousands of hectares, but it hardly ever gives useful tracts of land to the small guy. I visited one big project in Rondonia, it belonged to a firm that grew powerful in the South by devastating the Araucaria forests. Some 20 000 ha were being put to pasture and an area much bigger was being logged. On this project the company closed the road by which the seringueiros not affected by the project used to bring out their rubber and instead forced them to sell all the rubber to the company at prices far below market prices.

Indians, caboclos and seringueiros are compatible with the survival of the forest. Their lifestyle could easily be improved socially and ecologically by teaching them better cropping and collecting or fishing methods, storage methods and hygiene. Almost nothing is being done in that direction, even though some very interesting research work already carried out at INPA has shown how permaculture with palm trees, bread fruit and others can produce up to 10 times as much food per acre as the shifting agriculture now practiced by the caboclo and seringueiro But ofi cial philosophy sees only backwardness in subsistence farming, even if it makes people happier. There is also no concern whatever for sustainability.

In Rondonia it is very easy to see how devastation, even when it is commited by small people, is always caused by the shortsightedness and greed of the powerful. The settlements now demolishing the forest in Rondonia are part of a classical colonialist structure of dependence and export. In the new towns of Rondonia, growing like mushrooms, it is almost impossible to find locally produced articles in the shops. Everything, even the broiler or the salad in the restaurant, come from the industrial south. While enormous quantities of wood go up in smoke or rot on the fields people cook with bottled gas brought in by truck over two and a half thousand kilometers. Local power staions also burn petroleum that comes by truck after crossing the ocean on its way from the Persian Gulf. The central electricity board will not allow large timber mills, like the one in the city of Ji Paraná, that has sufficient furnace capacity and wood tailings to produce electricity. Whe the Madeira River passes the capital of Rondonia, Porto Velho, one can see thousands of tons of wood, logs, branches, whole trees, floating downriver. No attempt is made to use that wood. When a region has to import every thing it consumes it must pay with exports. Hence the agricultural policy of promoting only cash crops.

While unsustainable forms of agriculture are destroying the tropical rain forest in Rondonia, the regions in the South, from where many of the migrants come, such as the fertile and deep red soils of Paraná, Santa Catarina and Rio Grande do Sul are also being raped. Soybean monoculture to feed cows in the Common Market, rather than people in Brazil, is causing erosion on a scale never seen before. All the rivers are dark brown or red with clay and silt. Monoculture is also destroying what is left of peasant culture. These soils could support a sustainable form of highly productive and diversified agriculture. Now, food production in the formerly peasant regions is going down drastically. In the more mountainous areas of Santa Catarina farmers plant corn on steep slopes, at enormous costs in terms of erosion, for chicken farms for export to Saudi Arabia. The farmers often buy their food in the supermarket, eggs and vegetables imported from São Paulo.

If the methods of organic farming were promoted on the good, fertile soils in the South, the North East and in central Brazil, and only in those areas already reclaimed, without touching remaining wilderness, this would dramatically increase productivity with less pollution and erosion. Migration could cease, it could soon be reversed. Those who are bound to be in trouble soon in Rondonia could come back. Today, with all the paraphernalia of heavy and sophisticated machinery, soluble fertilizers and poisons, the regions with the most "advanced" agriculture have very low productivity. In the soybean-wheat monocultures (soybean in summer, wheat in winter, in subtropical climate) that now cover most of the good soils in the three southernmost states average production is below 800 kg/ha for wheat (!) and around 1500 kg/ha for soybeans. Any small step in the direction of organic soil management, more crop diversification, crop rotation, green manure, composting of farm and industrial organic residues (in my home state alone more then ten million tons of organic industrial residues are wasted annually) would immediately lead to dramatic increases of productivity with equally significant increases in employment. We need not give up our present exports and could still produce more food. We already have a few examples of farms attesting to that.

Amazonia should be left to the Amazonians, it is theirs. The growth of capital and power at the expense of the ecology and the people of Amazonia is classical imperialism. It makes no difference whether the benefits accrue to powers from overseas or from other parts of Brazil.

There is one more issue that must not be forgotten. Studies such as those of Salatti (University of Piracicaba) have shown that the climate is largely generated by the forest itself. Evapo-transpiration is so intense that 50% or more of rain water is put back into the atmosphere. The rain that falls on the

slopes of the Andes is water that has been recycled between 5 and 7 times on its way from the Atlantic. The whole system of recycling may break down if the chain in interrupted at the start. But exactly this is being done today. As we saw in the beginning of this article, the forest of Pará may be gone by the year 1990. Already now we have an exceptional drought on the Island of Marajó in the mouth of the AMAZON River. Where the forst, dissapears, intensive evapotranspiration gives place to naked soils that heat up to 50ºC or more in the hot ropical sun producing hot upwinds that dissolve clouds instead of producing them as does the forest. The rainfall pattern may change all along to way to the Andes. The rain forest, with its shallow root system, cannot stand long periods of drought. In this respect it is fundamentally different from the savannah (cerrado) forests farther south where vegetation has very deep root systems. Before it dies, the rain forest may become combustible. Already around Belém a few weeks of drought give rise to brush fires. The first fires may not kill the forest, but successive fires over a few years will do it. Brazilian pyromania is proverbial. A process of successive demolition may set in.

I have already observed another type of self-demolition on some of the lower areas of flood plains. Some of the igapós (flood plain forest) are dying without being touched by chainsaw or defoliant. Deforestation in the upper Amazon basin, such as in Rondonia and Peru unbalances the flow of the river. Floods are higher than normal, drought is more prolonged. The igapó community gets more and less than it can stand.

Collapse of the rainforest or large scale deforestation will inevitably lead to changes in regional climate. It is defficult to see how a serious change in regional climate will not affect world climate. The Amazon rainforest ist evenly spread over both hemispheres. The fresh water that flows and is recycled through this well balanced system constitutes about one quarter of total world river flow. Together with the carbon dioxyde balance, the ozone layer, aerosols, dusts, cloudiness and albedo, all of which are being systematically and blindly disturbed by modern industrial society, the Amazon rainforest is one of the important regulatory mechanisms of world climate.

Those of us who live in temperate or subtropical climates should perhaps be the most concerned. A change in world climate, even small, will affect us more than the tropics. During the ice ages or inter-glacial periods temperatures on the equator did not change very much but the tropical belt shrank or broadened, the subtropical and temperate belts moved towards or away from the equator. It is easy to imagine what this will mean for Europe, Asia, the US, southern Africa, southern South America, Australia.

In our fight for ecological sanity we must always keep in mind that social justice and a healthy environment go together. Humanity will only abandon its present suicidal course when the masses become ecologically conscious and exert enough pressure on the powerful, whether they be multinationals, local oligarchies or governments of whatever denomination.

Brazil's policies concerning the Amazon must change, they must change during this decade, or it may be too late !

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